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Volume XXXIV

1925

PUBLISHED FOR
The American Psychological Association
By THE PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.
and ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.)
Paris (16 rue de Condé)

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VOL. 34 NO. 1 | PSYCHOLOGICAL REVIEW PUBLICATIONS | WHOLE NO. 154 1925

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S. W. FERNBERGER, UNIVERSITY OF PENNSYLVANIA (*Bulletin*)

Studies from the Psychological Laboratory of the University of Chicago

The Influence of Tuition in the Acquisition of Skill

BY

TSU LIEN WANG, PH.D.

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ACKNOWLEDGMENTS

The present research was conducted under Professor Harvey A. Carr, who is not only responsible for devising the problem but also for the searching analysis of the data and the revision of the manuscript. To him the writer wishes to acknowledge his deepest obligation.

Acknowledgment must also be made of Professors Rutledge T.Wiltbank and Forrest A. Kingsbury, whose assistance in securing the subjects for this research has been invaluable.

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CHAPTER I

Introduction

In almost all the work on learning the experiments are conducted in such a way that the subject performs the assigned task without any interference on the part of the experimenter during the period of learning. In the experimental work on memory, for instance, the subject is given some kind of material to learn; but in no case does the experimenter offer him any assistance or suggestion during either the process of memorizing or recall. In acquiring acts of skill, the subject does not receive any coaching from the experimenter during the period of practice. In learning a maze the subject is asked to master the problem in as short a time and with as few errors as possible. During any one trial or in any part of the experiment, he is given no aid. In fact, in most of the experiments on learning the experimenter purposely takes the precaution to avoid influencing the subject in any way either by word or manner.

On the other hand, the experimenter may purposely introduce some suggestion, advice or guidance from time to time, in order to study its effect upon the process of learning. Such an attempt on the part of the experimenter to give some assistance to the subject while learning may be called a process of tuition.

In human psychology the only work devoted exclusively to the study of the influence of tuition upon learning is that of Miss Ludgate on "The Effect of Manual Guidance upon Maze Learning."[1] Tuition was given in the form of manual guidance. The experimenter guided the subject's hand over the correct pathway of the maze for a given number of trials and let him complete the learning without further assistance. She found that such guidance was helpful in most cases. In the field of animal psychology the tuition method has been used by Thorndike.[2] He put his cats through some problem boxes, but concluded that this

[1] Ludgate, Katherine E., "The Effect of Manual Guidance upon Maze Learning." Psychological Review Monograph Supplement, Vol. XXXIII, No. 148.
[2] Thorndike, Edward L., "Animal Intelligence," Psychological Review Monograph Supplement, Vol. II, No. 4.

mode of tuition was not very successful. Lashley,[8] in the study of the relation of the distribution of practice to the rate of learning adopted the tuition method in one case in which "the animals were not allowed to correct the errors but were returned immediately to the starting compartment if they entered a *cul de sac* or turned back along the correct path." Here tuition did produce a beneficial effect.

The purpose of the present investigation was to study the influence of verbal means of tuition upon maze learning. Two forms of tuition were employed: (1) The method of Instruction and (2) The method of Information. In the first method, the subject was guided over the correct pathway by being told in which direction to move the stylus, in order to discover the effect of error prevention upon the ability to learn the maze. In the second method, the subject was informed of each error as it was made in order to ascertain whether a knowledge of one's mistakes will aid in their elimination. This information was imparted in one of three ways: (1) By counting after the completion of each error: The subject was informed that the experimenter would count aloud each error just after it was made. (2) By counting at the beginning of each error: In this case the experimenter counted aloud just as the subject started to enter a *cul de sac* or to return over the true path. (3) By naming each error after it was made. The experimenter called out 'blind' for each entrance into a *cul de sac* and 'backward' for each return over a section of the true pathway. Care was taken to prevent all other sources of suggestion beyond those enumerated. No other verbal comment of any sort was made while the maze was being mastered. All visual sources of suggestion were eliminated by the use of a screen which entirely shielded the experimenter from the sight of the subject.

Problems

The problems involved in this investigation may be set forth in the following series of propositions:

(1) To study the influence of tuition in maze learning by com-

[8] Lashley, K. S., "A Simple Maze: with Data on the Relation of the Distribution of Practice to the Rate of Learning," Psychobiology, Vol. 1, No. 5.

paring the results of the groups which learned the maze with a given amount of tuition with those that mastered the maze without such aid.

(2) To determine the relative efficiency of the various forms of verbal tuition used in this investigation.

(3) To study the relative effect of different amounts of tuition upon learning.

(4) To investigate the effect of introducing tuition at various positions during the process of learning.

(5) To study individual and sex differences in learning.

Apparatus

The apparatus was the stylus maze (see FIG. 1) used by Miss

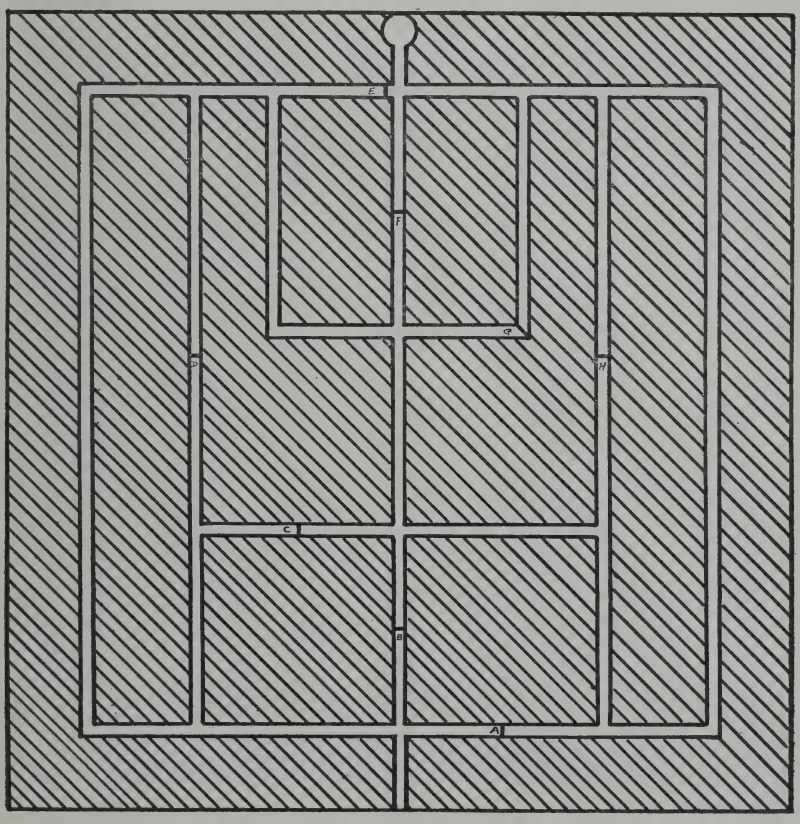

FIGURE I

Ludgate in her research referred to above. Its dimensions were 41.5 cm. by 42.0 cm. The correct pathway had length of 174 cm. and the blind alleys, 119.3 cm. The stylus consisted of a small circular disc, 2 cm. in diameter, which was attached to the hard rubber handle by a ball and socket joint. The maze was so constructed that the stylus could not be removed from the grooves except at the entrance or at the goal end. The stylus was inserted in the groove at the entrance and the subject was instructed to discover the location of the goal end. When the goal was reached, thus marking the end of a trial, the stylus was removed from the groove and placed back at the starting point for the next trial. The maze was firmly fastened to a small table. Over it was erected a square wooden framework of a height of about 40 cm. The whole frame was covered with black canvas save on the side towards the experimenter. This arrangement hid the maze and the experimenter from the sight of the subject, but allowed the experimenter to watch the subject's movements while mastering the maze.

Procedure

Three hundred and fifteen subjects mastered the maze under twenty-six different conditions. Almost all of the subjects were drafted from the classes of introductory psychology. A great majority of them were either sophomores or juniors in the university. All were without any previous maze experience.

Before each subject started the experiment, a typewritten sheet of General Instructions and another sheet of Special Instructions for his particular group were handed to him. Only the General Instructions sheet was given to the members of the normal group. The subject was requested to read the Instructions carefully and to delay the beginning of the experiment until he thoroughly understood them. The General Instructions follow:

"When the experiment begins, sit squarely in front of the table as closely as convenient. Place your hand beneath the curtain and I will give you a stylus. Use either hand you prefer. Hold the stylus in the vertical position and do not allow your hand to come in contact with the maze during the course of the

experiment. The stylus moves freely in the grooves of the maze. There is but one place in the maze where the stylus can be lifted out of the groove. The object of each trial is for you to move the stylus about in the grooves, exploring all paths in the attempt to discover this place with as few moves as is possible. I will inform you when you reach this position, in case you do not recognize it. There is but one correct route from the beginning of the maze to this goal and the route remains constant from trial to trial. In addition to the correct pathway there are a number of blind alleys. Any entrance into a blind alley, and any retracing of the correct path will be counted as an error. The object of the experiment is to learn in as few a number of trials as is possible to move the stylus over the correct path without making any error. The maze will be considered learned when you are able to make four correct trials in succession. Use any speed you prefer. Speed does not count in the records."

The Special Instructions for each group will be given later.

As soon as the subject started to work, the experimenter refrained from any kind of utterance, except that which has been specified. The screen eliminated all possibilities of suggestion from the experimenter's facial expression or bodily movements. The subject was required to finish the experiment in one sitting. Between trials a rest of a few seconds was always required. Brief periods of rest were also permitted during the long initial trials. These intervals of rest were interpolated at the discretion of the experimenter.

The subjects were required to master the maze until they were able to run four perfect trials in succession. For each trial there were recorded the time in seconds, the total number of errors, the number of *cul de sac* and return errors, and the number of errors made for each *cul de sac*. Some of the detailed data were desired for the study of individual differences. It was purposely stated in the General Instructions sheet that "speed does not count" so as to allow full play to the individual's peculiarities in the time record.

The experimental conditions were kept as nearly constant as possible. The experiments were always conducted in the same

room and at various times during the day. In order to minimize the diurnal effect, the time of experimentation for the subjects in any one group was distributed as widely as possible throughout the day. The possibility of sex differences was also taken into account and minimized by distributing as equally as possible the number of both sexes in any group.

Group Notations

In order to avoid confusion, the various groups of subjects were given different notations. Capital letters indicated the kind of tuition employed; numerals, the amount given; and small letters, the position in which it was given. Thus A-1-a, for example, means that the A form of verbal suggestion was given during the first trial only.

The notations for the different groups are:

N = Normal group in which no tuition was employed.

D = Groups where verbal instructions were given.

A, B, and C = Three modes of giving information (A = counting at the completion of each error; B = counting at the point of making each error; C = naming each error after it was made.)

CHAPTER II

The Instructional Method of Tuition

The experiments reported in this chapter were conducted in order to ascertain the effect of guidance by means of verbal instructions upon the process of learning a stylus maze. By means of these instructions the subjects were guided over the correct pathway for a given number of initial trials, and thereafter they were required to complete the learning of the maze without any further aid. This procedure prevented the subjects from making any error during the guided trials and the experiment was designed to study the effect of this initial guidance upon the subsequent unguided trials.

Five groups of ten subjects each received different amount of verbal instruction during the initial trials. They are designated as the controlled groups. The conditions under which these groups learned the maze are summarized in the following table:

TABLE 1

Conditions for the Controlled Groups

Group Designation	No. of Subjects	No. of Initially Guided Trials
D-1 -a	10	1
D-2 -ab	10	2
D-4 -abcd	10	4
D-8 -a...h	10	8
D-16-a...p	10	16

For all of the controlled groups the typewritten General Instructions were read by the subject. In addition to this a typewritten sheet of Special Instructions was also read by each subject. The Special Instructions for the different groups were the same except that the number of the guided trials was specified differently for each group. The Special Instructions sheet for group D-1-a is given as an example:

"In your case, I shall give you *during the first trial only* verbal instructions while running the maze, which if followed carefully

will enable you to run the maze without error. As you approach a critical point in the maze, I will say aloud 'right,' 'left,' 'forward' or 'backward' as the case may be. In case you make an error in spite of the instructions, I will say 'turn back.' If you go relatively slowly, and follow the instructions carefully, no error will be made. The purpose of this experiment is to discover whether these instructions given for a certain number of trials will enable you to run the maze more readily than you would without them."

The results of these controlled groups are to be compared with those of a group of fifteen subjects, who learned the same maze without any verbal instructions. This group is known as the normal (N). These results can also be compared with some of Miss Ludgate's data in order to study the relative effect of verbal and manual guidance.

Two problems will thus be investigated in this chapter.

1. Is the method of error-prevention by means of verbal instructions an aid in learning? What is the relationship between the amount of verbal instruction and the degree of its effectiveness?

2. What is the relative value of verbal and manual means of guidance?

1. *The Effect of Verbal Instruction upon Learning*

The comparative data for the first problem are given in tables 2 and 3. Table 2 gives the average scores per individual for trials, the number of retracing and *cul de sac* errors, the total number of errors, the average number of errors per trial, and the final speed in seconds (*i.e.*, the average speed for the last four trials). In this and in all the later tables the individual variability within a group is expressed in terms of M.D. Table 3 gives the percentages of saving for each of these items for each of the controlled groups.

TABLE 2

Records of Normal and Controlled Groups

Groups	Trials	Errors			Errors per Trial	Final Speed
		Retrac.	Blind	Total		
N	31.6 ± 9.33	67.4	138.7	206.1 ± 88.91	7.11	12.68 ± 1.64
D-1 -a	21.9 ± 4.90	31.9	78.7	110.6 ± 82.64	4.21	25.70 ± 17.22
D-2 -ab	19.0 ± 7.00	15.4	40.8	56.2 ± 56.28	2.25	22.23 ± 7.65
D-4 -abcd	16.5 ± 7.26	5.6	14.0	19.6 ± 17.44	1.03	26.80 ± 12.79
D-8 -a...h	28.2 ± 7.40	8.5	26.1	34.6 ± 24.96	1.14	23.42 ± 7.83
D-16-a...p	33.0 ± 7.60	8.8	16.8	25.6 ± 19.40	0.69	24.90 ± 10.54

TABLE 3

Percentages of Saving Due to Verbal Instructions

Groups	Trials	Errors	Errors per Trial	Final Speed
N	.....	.....	.....	.....
D-1 -a	30.82%	50.71%	40.93%	—102.68%
D-2 -ab	39.98	72.73	68.35	— 75.31
D-4 -abcd	47.88	90.48	85.51	—111.36
D-8 -a...h	10.92	83.22	83.96	— 84.70
D-16-a...p	—4.23	87.58	90.29	— 96.37

The factual data may be summarized as follows:

(1) With one exception verbal guidance operated to decrease the number of trials required to learn the maze, the total number of errors, and the average number of errors per trial. It increased the record for the final speed.

(2) On the average, verbal guidance affected the score for the final speed most, the error record next, and the trial record least. The records of the guided groups showed a saving of 76.94% and 25.49% respectively for errors and trials, and a loss of 94.08% on final speed.

(3) The efficacy of the guidance as measured by the trial and error records varied with the amount of guidance given. In a general way, its effectiveness at first increased and then decreased, as the number of the guided trials was increased. When the ef-

ficiency of the guidance was measured by the record for the final speed, there was no definite relationship between the amount of guidance and the degree of its effectiveness. Four guided trials was the most effective number employed. It exerted the most effect upon the records for trial, error and final speed.

(4) Guidance exerted a slightly greater effect upon the amount of retracing than it did upon the number of entrances into the *cul de sacs.*

(5) Guidance increased the relative amount of individual variability in the records for error and final speed. No consistent effect upon the trial records can be noted.

The pronounced effect of the guidance upon the error record is due in the main to the fact that no errors were made during the guided trials. The saving in errors due to the immediate effect of guidance is given in the fourth column of Table 4. As one would naturally expect, the number of errors prevented increases with the number of the guided trials.

TABLE 4

Error Reduction Due to Guidance

Groups	Total Errors	Total Saving	Saving during Guidance	Saving after Guidance
N	206.1	.....	....	....
D-1 -a	110.6	95.5	79.1	16.4
D-2 -ab	56.2	149.9	101.8	48.1
D-4 -abcd	19.6	186.5	137.9	48.6
D-8 -a...h	34.6	171.5	168.9	2.6
D-16-a...p	25.6	180.5	191.5	—11.0

Guidance also exerted an effect upon the error records of the subsequent period of learning. This is apparent from an inspection of tables 4 and 5. The fifth column of table 4 gives the total number of errors saved for each guided group during the post-guided period of learning. Four guided trials exerted the greatest effect, while the influence of sixteen guided trials was detrimental.

TABLE 5

Error Records for the First Twenty Trials

Trials	N.	D-1-a	D-2-ab	D-4-abcd	D-8-a..h	D-16-a...p
1	79.1	0	0	0	0	0
2	22.7	24.5	0	0	0	0
3	16.5	20.4	10.1	0	0	0
4	19.6	20.7	5.2	0	0	0
5	6.3	9.9	4.8	2.6	0	0
6	12.9	7.4	8.6	3.2	0	0
7	6.2	3.5	2.9	2.6	0	0
8	5.6	5.5	2.0	1.6	0	0
9	2.8	2.3	3.4	.8	10.6	0
10	3.2	2.9	1.5	.9	2.1	0
11	2.9	1.6	1.2	.7	2.7	0
12	3.8	1.2	3.2	.7	1.9	0
13	3.4	1.7	1.0	.6	1.1	0
14	2.8	1.1	1.0	.4	.7	0
15	2.1	.7	.9	.2	2.0	0
16	1.6	.8	1.1	1.4	1.7	0
17	1.7	.4	.5	.6	.7	3.5
18	1.4	.1	.5	.5	.7	1.6
19	1.6	1.1	.3	1.1	1.4	1.1
20	.6	.5	.6	0.0	.7	.6

In table 5 are given the error records of the various groups for the first twenty trials. It will be noted that the groups given 2 and 4 guided trials have an initial error record which is lower than that of the normal group after a similar number of unguided trials. In other words, groups given 2 or 4 guided runs reach a more advanced stage in the mastery of the problem than they would have attained if allowed a similar number of unguided runs. On the other hand, the groups given 1, 8 and 16 guided trials made a poorer initial error record than did the normal group after a corresponding number of unguided trials.

It is evident that the subjects learned a considerable amount about the maze during the guided trials, and that this knowledge was utilized effectively in completing the mastery of the problem during the post-guided period of learning.

Subjects can learn more from 1 to 8 guided trials than they can from an equal number of unguided runs. Sixteen guided trials, however, are less effective than sixteen unguided ones.

The fact that the effectiveness of the guidance first increased and then decreased with the number of trials in which it was given can be explained in the following manner: Guidance is effective because it enables the subject to acquire a knowledge of the nature of the true pathway. Only so much can be acquired in this manner and after this limit has been reached, any additional guidance will be superfluous and possibly detrimental. (1) All superfluous trials will necessarily increase trial and error records. (2) Any excessive amount of guidance is apt to develop either an attitude of over-confidence or a habit of dependence. Over-confidence leads to carelessness and many unnecessary errors are made and more trials are required for their elimination. The subject develops the habit of relying upon the experimenter, and becomes confused and helpless when thrown upon his own resources. Extra time is required in order to adjust to the new situation.

That guidance exerted a slightly greater effect upon the amount of retracing than it did upon the number of entrances into the blind alleys can be explained by the fact that it gave the subject a knowledge of the general direction of the correct pathway, which favored the elimination of the retracing errors. On the other hand, this knowledge of the general direction did not insure the elimination of *cul de sac* errors to the same extent.

That guidance operated to decrease the final speed for all the controlled groups can be accounted for by the fact that it induced within the subjects an attitude of caution which means delay in movement. In the cases in which a very small amount of guidance was given, this attitude developed during the period of guidance persisted in the subsequent trials, and thus decreased the final speed. When a large amount of guidance was given, it strengthened this attitude to such an extent that the subjects were accustomed to go slowly around the maze.

That verbal guidance tended to increase the relative variability of the groups in the records for error and final speed may be accounted for by the fact that individual differences in the ability to learn the maze were emphasized to a greater extent with guidance than without. The range between the best and the poorest learn-

ers in the normal group is far smaller than that in most of the controlled groups.

2. *The Relative Value of Verbal and Manual Guidance*

Since the maze employed in our investigation was the one which had previously been used by Miss Ludgate, it is possible to compare the value of the two methods of guidance. Five groups of subjects in each experiment were given similar amounts of guidance. The comparative data are given in table 6. "Manual" refers to Miss Ludgate's data and "Verbal" to ours.

Miss Ludgate used as her criterion of learning the ability to make four perfect runs in five attempts. Our criterion is four perfect successive trials. In order to make the conditions comparable, we have computed our data as given in table 6 on the same basis as that employed by Miss Ludgate. This procedure accounts for the fact that our records as given in table 6 differ slightly from those given in table 2.

TABLE 6
The Relative Value of Verbal and Manual Guidance

No. of Guided Trials	Trials		Errors	
	Manual	Verbal	Manual	Verbal
0	28.8	27.9	194.5	203.66
2	23.2	18.8	53.4	56.2
4	29.1	15.8	72.0	19.6
8	27.5	25.3	69.8	33.6
16	41.1	27.8	43.2	22.4

The results for the two normal groups, those to whom no guidance was given, are approximately identical. This fact indicates that the comparison of the two sets of data is legitimate.

The verbal method of guidance is the more effective with the single exception of the error record for the group with two guided trials.

The two methods differ in the number of trials required to secure the optimal effect. With manual guidance, two trials exert the greatest effect, while four trials are required for the verbal method.

These results must be explained in terms of the differences between the two methods. In Miss Ludgate's experiment, the subject grasped the stylus and the experimenter moved it over the correct pathway at a uniform rate. The subject was requested to maintain as *passive* an attitude as possible. The experimenter was responsible for the motion of the stylus. Our subjects assumed an *active* attitude. They voluntarily initiated and executed the movements in response to our direction. The rate of motion was subject to their discretion.

The greater effectiveness of the verbal method of guidance is to be explained in terms of this difference of volitional attitude toward the task. It is assumed that a subject will learn more about the nature of the requisite arm motion when it is actively performed than when it is passively executed.

The fact that the two methods differ as to the number of trials required to develop their maximum effectiveness can be explained in two ways: (1) We may assume that very much more can be learned about the true path with the active method of traversing it, and hence that more trials are required to attain this limit of effective knowledge in spite of the greater efficiency of each trial. (2) The manual or passive method is more conducive to the development of the attitudes of carelessness and dependence upon the experimenter. These attitudes are developed more quickly, and as a consequence their detrimental effects begin to manifest themselves after a fewer number of trials.

CHAPTER III

The Informational Method of Tuition

With the informational method of tuition, three groups of fifteen subjects each were employed. These groups are known as A, B, and C respectively. Group A was given the first form of the information method; Group B, the second; and Group C, the third. In all cases the information concerning their errors was imparted during every trial involved in learning the maze. The Special Instructions given to the members of each group were as follows:

Group A: "In your case, I shall count out loud the number of errors as you make them. I shall count after you have completed the error—after you have reached the end of a blind alley, or after you have traversed the full length of a straight section when retracing the correct path. This procedure will inform you of every error after you make it. The purpose of the experiment is to discover whether this knowledge will enable you to learn the maze more readily."

Group B: "In your case, I shall count out loud the number of errors as you make them. In each case I shall count just as you start to make the error, *i.e.*, just after entering a blind alley and whenever you start to retrace over the correct path. This procedure will inform you of every error just as you are beginning to make it. The purpose of the experiment is to discover whether this knowledge will enable you to learn the maze more readily."

Group C: "In your case, I shall inform you of every error you make, whether the error is an entrance into a blind alley or a return over the correct path. I shall say 'blind' after you have reached the end of blind alley, and 'backward' after you have retraced the full length of a straight section of the maze. The purpose of this experiment is to discover whether this knowledge will enable you to learn the maze more readily."

The results of the above groups are compared with those of the normal group of fifteen subjects who learned the maze without assistance. The comparative data are given in tables 7, 8,

and 9. Table 7 gives the gross records, table 8 the percentages of saving resulting from those means of tuition, while in table 9 are found the error records for the first fifteen trials.

TABLE 7

Records of Normal and Controlled Groups

Groups	Trials	Errors			Final Speed
		Retracing	Blind	Total	
N	31.66 ± 9.33	67.4	138.7	206.13 ± 88.91	12.68 ± 1.64
A	22.27 ± 8.32	28.8	74.3	103.2 ± 63.22	21.81 ± 8.16
B	24.93 ± 7.38	20.7	58.2	78.9 ± 40.66	20.64 ± 7.58
C	21.33 ± 7.37	18.1	42.1	60.2 ± 28.66	25.36 ± 9.95

TABLE 8

Percentages of Saving due to a Knowledge of Errors

Groups	Trials	Errors		Final Speed
		Retracing	Blind	
N	.....	.....	.....	.....
A	29.65%	57.27%	46.43%	—72.01%
B	21.25	69.28	58.03	—62.77
C	32.62	73.14	69.64	—100.00

TABLE 9

Error Records for the First Fifteen Trials

Trials	Normal Group			Group A			Group B			Group C		
	R	B	T	R	B	T	R	B	T	R	B	T
1	32.1	46.1	78.2	14.5	27.3	41.8	5.1	10.7	15.8	4.9	10.8	15.7
2	7.8	14.8	22.6	6.5	12.7	19.2	4.0	8.1	12.1	4.6	8.1	12.7
3	5.5	11.1	16.6	2.1	5.8	7.9	1.8	6.4	8.2	1.8	4.4	6.2
4	7.7	12.6	20.3	1.1	4.3	5.4	3.5	6.7	10.2	1.4	4.3	5.7
5	1.4	4.9	6.3	0.1	2.1	2.2	1.8	4.2	6.0	1.6	4.1	5.7
6	3.9	9.1	13.0	1.3	3.3	4.6	2.1	5.3	7.4	1.0	3.6	4.6
7	1.8	4.5	6.3	0.1	1.1	1.2	0.4	1.7	2.1	0.5	2.0	2.5
8	1.3	4.3	5.6	0.1	1.4	1.5	0.5	1.9	2.4	0.6	1.9	2.5
9	0.4	2.5	2.9	0.0	1.2	1.2	0.4	2.1	2.5	0.3	1.9	2.2
10	0.5	2.5	3.0	0.3	1.8	2.1	0.2	1.0	1.2	0.2	1.5	1.7
11	0.3	2.6	2.9	0.0	0.6	0.6	0.1	1.3	1.4	0.07	0.5	0.57
12	0.9	3.0	3.9	0.07	1.2	1.27	0.3	0.9	1.2	0.1	0.8	0.9
13	0.8	2.9	3.7	0.07	1.0	1.07	0.2	1.0	1.2	0.2	0.7	0.9
14	0.9	1.9	2.8	0.2	1.07	1.27	0.0	4.1	4.1	0.07	0.8	0.87
15	0.2	1.9	2.1	0.07	0.9	0.97	0.07	6.0	6.07	0.07	0.7	0.77

R—Retracing; B—Blind Alley; T—Total.

The experiments were designed to answer two general questions: (1) To what extent will this information be utilized in learning the maze? Will a knowledge of one's mistakes obtained in this manner be of any aid in their elimination? (2) What is the relative value of the three forms of the informational method?

The comparative data of the above tables justify the following conclusions:

The information imparted to the subjects concerning the errors operated to decrease the records for trials and errors. But it retarded the final speed.

This knowledge exerted the greatest effect upon the records for the final speed, next upon the error records, and least upon the trial records.

The information exerted a slightly greater effect upon the errors due to retracing than upon those due to entrances into the *cul de sacs.*

It is a noteworthy fact that this information very materially reduced the number of errors in the first trial. For the three groups A, B and C, the percentages of saving in the first trial were 46.5, 79.8 and 79.9. The corresponding percentages for the entire period of learning were 49.98, 61.22 and 70.79.

These methods of information exerted no consistent effect upon the relative amount of individual variability within a group.

The third type of information (Method C) was the most effective, when measured in terms of trials, errors and final speed.

Method B was more effective than A in reducing the error record but less effective in decreasing the number of trials required to learn the problem and the average final speed employed to go over the correct path. The greater effectiveness of method B upon the error records was manifested in the initial trial.

In the usual method of learning the maze, errors may apparently be made and eliminated without any ideational knowledge of their existence. On the other hand, in the controlled groups, especially in the later stages of learning, the subject does come to recognize many of his errors, and presumably this knowledge of one's mistakes will aid in their elimination. To what extent errors are made and eliminated without knowledge and to what

extent their elimination is due to this knowledge we do not know.

Our experiments, however, do prove that such knowledge may be used effectively, for any information imparted to the subjects in addition to that which they discover on their own initiative very materially reduces the time required to learn. The members of the controlled groups who were informed of each error at the time it was made were able to master the problem much more readily than those subjects who were given no aid.

One may also infer from these records that many of the errors made in the normal method of learning the maze are wholly unnecessary. In other words, many might be dispensed with without affecting the number of trials required to master the problem. This hypothesis is supported by the fact that the information given to the subjects operated to reduce the error record much more than it affected the number of trials.

In the usual method of learning, the subjects, in their retracing excursions, naturally return a considerable distance toward the entrances to the maze. The information very materially reduces the distance of these returns, for the subjects naturally turn back when informed of their error. Since a section of the path constitutes the unit of error, the information will necessarily reduce the number of the retracing errors. Since *cul de sac* errors may be made while retracing and again while retraversing the section that has just been retraced, it is evident that any prevention of retracing will also reduce the number of entrances into the *cul de sacs*. With much retracing the subject becomes confused, lost and helpless, and many additional errors are made as a result of this confusion. This information serves the purpose at least of reducing the extent of the retracing excursions and thus incidentally affects the number of both types of error. This conception probably explains the fact that tuition was effective during the initial trial.

In learning a maze, other things being equal, the oftener one goes through it, the faster he travels. In the normal group, the subject on the average went through the maze thirty-two times before they mastered it, while in the controlled groups the number was about twenty-three. Naturally the final speed for the

former is greater than that for the latter. There is also another way of accounting for this difference. In the normal group the subject performs the task on his own accord. In the controlled groups the subject is constantly reminded of the mistakes as they are made. This outside influence tends to make him work more carefully. Caution implies hesitancy in work which in turn means slow movement and low speed.

Methods A and C are alike except that in the latter case the subjects are given the additional information as to the kind of error made. This additional knowledge accounts for the greater effectiveness of the latter method of tuition.

Methods A and B differ as to the time when the information was given. In the first case, the information was imparted at the end of a runway,—after the error was completed. In the latter method, the information was given just as the runway was entered. The two methods induced different attitudes on the part of the subjects. The information, when imparted at the end of *cul de sac,* will naturally exert no immediate effect upon the subject's behavior. This procedure develops more or less an attitude of indifference. When the information is given at the entrance of a *cul de sac,* the subjects immediately react by inhibiting the movement. This procedure develops an attitude of caution. The subjects attempt to anticipate and avoid these errors. This difference in attitude may account in part for the greater effectiveness of method B. A second explanation may also be suggested. In order to be effective in preventing an error, the information must be associated with the act of approaching it. The greater effectiveness of method B may be due to the fact that the information is imparted at a more opportune moment. The association is more readily established because of the closer temporal connection of the two factors. The study of the information method of tuition will be continued in the next four chapters, each taking up a special phase. Only the first type of information (method A) will be employed; the other two were discarded on various grounds. Method C was discarded on the ground that the terms "blind" and "backward" may be unconsciously confused. Method B was discarded on account of the greater difficulty of administration.

CHAPTER IV

Effect of Various Amounts of Information

In this chapter we shall report the experiments primarily concerned with the study of the effect of giving verbal information during a variable number of initial trials.

The 'A' form of verbal information—counting errors when completed—was used throughout.

Four groups of subjects were used in the experiments, two having ten each and two, fifteen. They mastered the maze under various conditions. In every case the subject received the verbal information concerning his errors during a given number of initial trials, and then completed the problem without further aid from the experimenter. A group of ten subjects received the information during the first trial only and it was designated as A-1-a. A second group of fifteen subjects was given the information during the first two trials; this was designated as A-2-ab. A third group of fifteen subjects learned the maze with the aid of verbal information during the first eight trials, this being designated as A-8-a..h. A fourth group of ten subjects received the verbal information during the first twelve trials. This was designated as A-12-a..l. The Special Instructions Sheet for each group was the same as that for group A except that the number of trials during which the verbal information was imparted, was specified in each case.

The results of each of these groups were compared with those of the normal group of fifteen subjects who learned the maze without any kind of information concerning their errors. The comparative data are given in tables 10 and 11. Table 10 gives the gross records for all these groups and table 11 shows the percentages of saving for each of the controlled groups over the normal group.

TABLE 10

Effect of Verbal Information Upon Learning

Groups	Trials	Errors			Final Speed
		Retracing	Blind	Total	
N	31.66 ± 9.33	67.4	138.7	206.13 ± 88.91	12.68 ± 1.64
A- 1-a	20.9 ± 8.68	42.7	94.3	137.0 ± 83.6	18.70 ± 3.95
A- 2-ab	20.4 ± 7.54	34.8	74.7	109.4 ± 54.86	18.17 ± 4.24
A- 8-a..h	18.2 ± 5.58	20.6	67.5	88.1 ± 23.34	22.74 ± 5.79
A-12-a..l	26.7 ± 9.36	33.2	90.4	123.6 ± 51.56	14.17 ± 3.77

TABLE 11

Percentages of Saving of Controlled Groups over Normal Group

Groups	Trials	Errors		Final Speed
		Retracing	Blind	
N	.....	.....	.....	.....
A- 1-a	33.98%	36.64%	32.01%	—47.47%
A- 2-ab	35.56	48.36	46.14	—43.29
A- 8-a..h	42.51	69.27	51.33	—79.33
A-12-a..l	14.81	65.57	34.82	—11.75

Two main problems will be considered in this chapter:

(1) Is the method of verbal information an effective aid in learning the maze, irrespective of the amount?

(2) What is the relative efficiency of the various amounts of verbal information?

The factual data may be summarized as follows:

(1) Verbal information, whatever the amount, imparted to the subjects, was effective in decreasing the number of trials required to master the maze, the total number of errors and retarding the final speed.

(2) It exerted the greatest effect on the final speed, next on error, and least on trial.

(3) It affected the retracing errors more than the *cul de sac* errors in the majority of cases.

(4) The group that learned with the aid of verbal informa-

tion during the first eight trials showed the best records in trial and error but the poorest in the final speed. Groups which received the information during either a fewer or greater number of trials made poorer records. The former excelled the latter in the number of trials required to master the problem but not in the total number of errors.

(5) There was no consistent relationship between the amount of verbal information received and the respective records for the final speed.

The superiority of the records of the verbal information groups over that of the normal group may be accounted for by two possible influences of the information: (1) the immediate and (2) the subsequent. These influences can be brought out by comparing the number of errors per trial in the controlled and uncontrolled periods with the corresponding data for the normal group. The following table gives these comparisons:

TABLE 12

Immediate and Subsequent Effect of Verbal Information

Groups	No. of Errors per Trial in					
	Controlled Period			Uncontrolled Period		
	No.	Cor. No. in N.	Saving	No.	Cor. No. in N.	Saving
A- 1-a	27.60	79.07	65.09%	5.49	4.1	—33.91%
A- 2-ab	24.26	50.86	52.28	3.31	3.5	5.96
A- 8-a.h	9.97	21.21	54.15	1.01	1.5	34.41
A-12-a.l	7.67	15.19	49.54	2.14	1.2	—78.33

For example, the group given information for the first two trials (A-2-ab) made an average error record of 24.26 per trial during the period in which the information was given, and an average error of 3.31 per trial for the subsequent period of learning. The error data of the normal group for the corresponding trials were 50.86 and 3.5 respectively. The percentages of saving due to the information are thus 52.28 and 5.96 for the two periods.

It is evident from table 12 that the immediate effect of the information is always beneficial. The percentages of saving apparently tend to decrease to a slight extent as the number of trials in which the information is given is increased. The subsequent effect of the information is sometimes beneficial and sometimes detrimental. Its effect varies in a pronounced manner with the amount of information given. Its influence is detrimental when the amount of information is either too little or too great.

The relative efficiency of varying amounts of information is a function of the combined influence of its immediate and subsequent effects. When both the immediate and the subsequent effects are beneficial, the combined effect always produces a better record than either one would alone. When the subsequent effect is detrimental, it becomes the controlling factor in determining the relative efficiency of these groups. Hence, A-8-a..h is the most efficient group not only because the combined effect is greater, but also because the subsequent effect is more beneficial than that of any other group. Group A-12-a..l is the least efficient, because the detrimental effect of the information on the subsequent uncontrolled trials is very much greater in this group than in any other one.

As a matter of fact in considering the relative efficiency of the controlled groups, we can easily dispense with the immediate effect of the verbal information, since this effect for each group is more or less on a par. The efficiency of a group is practically determined by the degree of the subsequent effect of the information. The following table gives the error records for the first fifteen trials for all the controlled groups. The asterisk indicates the error record made at the beginning of the post-controlled period. It is marked out so as to facilitate the comparison between this record and the corresponding one for the normal group.

The most efficient group is the one in which the subjects started at a more advanced stage of learning with the beginning of the uncontrolled period than did the normal group at the corresponding point (for instance, 0.9 *vs.* 2.9). The less efficient groups started at a comparatively less advanced stage (44.5 *vs.* 22.6 and 25.1 *vs.* 16.6).

TABLE 13

Error Records for the First Fifteen Trials

Trials	N	A-1-2	A-2-ab	A-8-a..h	A-12-a..l
1	78.2	27.6	33.8	25.4	24.7
2	22.6	44.5*	14.5	24.8	12.3
3	16.6	13.1	25.1*	12.3	23.8
4	20.3	12.1	17.1	5.5	10.9
5	6.3	7.5	5.2	3.9	7.3
6	13.0	9.4	2.9	2.0	4.4
7	6.3	2.8	2.3	1.8	5.4
8	5.6	3.1	1.7	1.8	4.3
9	2.9	1.9	1.9	0.9*	3.1
10	3.0	1.8	1.1	0.9	1.2
11	2.9	2.5	0.9	1.2	2.2
12	3.9	2.7	1.5	1.8	2.3
13	3.7	2.7	0.6	0.2	2.6*
14	2.8	0.4	0.8	2.0	1.2
15	2.1	0.6	0.4	0.3	1.6

The records for the final speed also throw some light on the discussion of the relative efficiency of the various controlled groups. There seems to be a negative correlation between the degree of efficiency and the speed of work. The most efficient group is the slowest group. The least efficient one gives the best speed record. Groups with the information given during a fewer number of trials are more efficient than the one in which the information is imparted to the subjects during a greater number of trials; the subjects in the former travelled much more slowly than those in the latter. These facts again confirm our contention that the low speed in the controlled groups as compared with the final speed for the normal group is due to the development of the attitude of caution on the part of the subjects in these groups, and that the information is responsible for the establishment of such an attitude.

The fact that the subsequent effect of the verbal information increases with the number of controlled trials and then decreases may be explained in the following manner: When the verbal information was given for one or two trials only, it could hardly be fixed in the subject's mind well enough to be utilized effectively in the subsequent uncontrolled trials. This difficulty became

greatly lessened, when the information was given in a greater number of trials. But when this number was greatly increased, the subjects developed an attitude of dependence upon the experimenter, and they were at a loss for a time after the control was removed. This setback naturally destroyed in part the subsequent beneficial effect of the information.

There is another reason why the information given for a fewer number of trials is comparatively more effective than that given for a greater number of trials. When a subject is told that he will receive aid during one or two trials only, he exerts more effort in them than if given a large number. On the other hand, when he knows that he will be given aid for a large number of trials, say twelve, he will distribute his effort in proportion to the number of controlled trials given. Naturally a subject will learn relatively more in two trials in the former case than he will in the latter. Inasmuch as about fifty percent of the total errors is usually made in the first two trials (48.25% for the four controlled groups and 53.05% for another three groups picked at random), the importance of these trials can not be overestimated. Hence, those who learn more during these trials make a better record than those who learn less. It may be argued that in the latter case the subjects can still learn in the controlled trials other than the first two, and the information received during these trials may influence the total record. This is quite true, provided that the number of these trials is not too great. That is why A-8-a...h is the most efficient group. But when the number of these trials becomes too great, the factor mentioned at the close of the last paragraph will operate to prolong the error record.

CHAPTER V

Effect of Information Given at Various Positions

The purpose of the experiments reported in this chapter is to study the effect of varying the position at which a given amount of verbal information is inserted.

Eight groups of subjects mastered the stylus maze under various conditions. Four groups each learned the maze with the information given during but one trial, viz., the first, second, fourth and sixth trials and they are designated respectively as A-1-a, A-1-b, A-1-d, and A-1-f. Four groups of subjects each learned the problem with the aid of the information during two trials, interpolated during the first and second, third and fourth, seventh and eighth, and eleventh and twelfth trials, and these groups are designated respectively as A-2-ab, A-2-cd, A-2-gh, and A-2-kl. Ten subjects each were employed for groups A-1-a, A-1-b, A-2-gh and A-2-kl, and fifteen subjects each for groups A-1-d, A-1-f, A-2-ab and A-2-cd. In each case the A form of verbal information was given. To each subject the amount of information and the position at which it was given were made known before the experiment was begun.

The results of these experiments were compared with those of the normal group of fifteen subjects who mastered the maze without the aid of information at any stage in the process of learning. The comparative data are shown in tables 14 and 15. Table 14 gives the gross records for all these groups, and table 15 gives the percentages of saving of each of the controlled groups over the normal group.

Three main problems may be suggested for discussion:

(1) Is a given amount of verbal information interpolated at various positions universally effective as a control?

(2) What is the position at which a given amount of verbal information produces the maximal effectiveness? What is the relative value of the various positions?

TABLE 14

Effect of Information Given at Various Positions

Groups	Trials	Errors			Errors per Trial	Final Speed
		Retr.	Blind	Total		
N	31.66 ± 9.33	67.4	138.7	206.1 ± 88.91	7.11	12.68 ± 1.64
A-1-a	20.9 ± 8.68	42.7	94.3	137.0 ± 83.60	7.08	18.70 ± 3.95
A-1-b	23.7 ± 5.96	44.7	98.9	143.6 ± 87.12	6.15	21.50 ± 4.25
A-1-d	23.4 ± 8.72	50.8	98.2	148.9 ± 54.88	6.51	19.38 ± 4.86
A-1-f	23.5 ± 9.70	40.0	87.3	127.3 ± 82.62	5.12	23.22 ± 10.24
A-2-ab	20.4 ± 7.54	34.8	74.7	109.5 ± 54.86	6.74	18.17 ± 4.24
A-2-cd	22.8 ± 9.22	41.7	82.7	124.4 ± 67.76	5.61	18.31 ± 4.44
A-2-gh	29.7 ± 8.16	42.8	117.8	160.6 ± 50.84	5.75	31.55 ± 10.45
A-2-kl	33.3 ± 11.3	55.3	109.9	165.2 ± 38.90	5.89	19.35 ± 2.38

TABLE 15

Percentages of Saving of the Controlled Groups

Groups	Trials	Errors	Final Speed
N	.....	.....	.....
A-1-a	33.98%	33.53%	—47.47%
A-1-b	25.14	30.33	—69.56
A-1-d	26.08	27.76	—52.92
A-1-f	25.77	38.24	—83.12
A-2-ab	35.56	46.92	—43.29
A-2-cd	27.98	39.65	—44.47
A-2-gh	6.19	22.08	—150.47
A-2-kl	—5.12	19.85	—52.65

(3) Does the optimal position remain unchanged irrespective of the amount of information given?

The factual results of the experiments reported in this chapter may be stated briefly as follows:

(1) Verbal information, regardless of the amount and the position at which it was given, was effective with one exception, in decreasing the total number of errors, the number of errors per trial, and the final speed for all the eight controlled groups.

(2) When the information was given during but one trial, its effect on the error records for the different groups was practically the same as that on the number of trials required to master the maze, with one exception. When it was given during two

trials, its effect on the error records was much greater than that on the trial records.

(3) Verbal information given at the initial position produced a greater effect upon the trial and error records than it did when given in any other position. This is true in all cases except one regardless of the amount of information imparted to the subject.

(4) With one exception, the information given at a later stage of the learning process was less effective upon the trial and error records than it was at an earlier stage. This is true whether the information was imparted to the subject during one trial or during two trials.

(5) There was no consistent tendency in the records for the final speed. No definite relationship between these records and the various positions at which the information was given was apparent.

(6) In general, the relative effect of the information upon the records for both the retracing and the *cul de sac* errors was practically the same.

(7) Information tended to increase the relative individual variability in the trial records in six out of eight cases, in the error record in five out of eight cases, and in the record for the final speed in all but one case.

(8) When the information was given during two trials, it produced a greater effect upon the trial and error records than it did when it was given during one trial in a similar position. This general statement is based upon comparisons between the results of group A-2-ab with those of groups A-1-a and A-1-b, and the results of group A-2-cd with those of group A-1-d in table 14.

The advantage of the controlled groups over the normal group may be further analyzed in terms of the immediate and the subsequent effects of the verbal information. These effects are shown in table 16, in which the number of errors per trial in the controlled and uncontrolled periods is compared with the corresponding data for the normal group.

For example, the group which received the information during the first trial (A-1-a) made an average error record of 27.60 per

TABLE 16

Immediate and Subsequent Effects of Verbal Information

Groups	No. of Errors per Trial in					
	Controlled Period			Uncontrolled Period		
	No.	Cor. No. in N	Saving	No.	Cor. No. in N	Saving
A-1-a	27.60	79.07	65.09%	5.5	4.1	—34.15%
A-1-b	8.20	22.66	63.81	3.4	3.5	2.85
A-1-d	7.70	20.26	61.84	2.6	2.4	—8.33
A-1-f	4.90	12.93	62.11	1.8	1.9	5.26
A-2-ab	24.26	50.86	52.28	3.3	3.5	5.96
A-2-cd	12.56	18.40	31.71	1.5	2.4	3.75
A-2-gh	5.25	5.93	11.46	2.1	1.5	—4.00
A-2-kl	2.55	3.40	25.00	1.4	1.3	—7.69

trial during the period in which the information was given, and an average record of 5.5 per trial during the subsequent uncontrolled period. The corresponding data for the normal group were 79.07 and 4.1. The percentages of saving and loss due to the operation of the information are 65.09 and —34.15 for the two periods.

The immediate effect of the information upon the error record, according to table 16, is always beneficial. The percentages of saving tend to decrease at first and then increase as the position at which a given amount of information is inserted is shifted towards the end of the learning period. This tendency is much more pronounced in the case in which the information is given during two trials than in the one in which it is given during but one trial.

The immediate effect of a greater amount of information is less than that of a smaller amount. But in general the subsequent effect of the former is greater than that of the latter.

The immediate effect of the information upon the error record is smaller when the information is given during the two trials than when it is given during either one of the two alone. The subsequent effect in the former condition is greater than that in the latter condition. These facts are borne out by comparing group A-2-ab with groups A-1-a and A-1-b, and group A-2-cd with group A-1-d with respect to their records for the immediate and the subsequent effect of the information (See table 16 for data).

The relative value of the various positions at which a given amount of information is inserted seems to be a function of the combined influence of the immediate and the subsequent effects of the information. When both the immediate and the subsequent effects are beneficial, the combined influence always operates to produce a better record than either one of them alone. When the immediate effect is beneficial, the degree of its effect does not necessarily determine the efficiency of the group. But when the subsequent effect is either beneficial or detrimental, it becomes the controlling factor in determining the value of a position at which a given amount of information is inserted. For example, among the four groups in which the information is given during one trial at various positions, group A-1-f made the least number of errors in the whole period of learning. This is due to the fact that the combined influence of the immediate and the subsequent effects is greater in this group than in any one of the other three. Among the four groups the immediate effect of the information upon the error record in group A-1-f is not so great as that in some other groups, but the subsequent effect in this group is greater than any, and hence it operated to produce the best error record for this group. On the other hand, among the four groups in which the information was given during two trials, group A-2-kl made the largest number of total errors. This is accounted for by the fact that the detrimental effect of the information upon the subsequent error record in this group is greater than that in any other group, e.g., group A-2-gh, although the immediate effect in group A-2-kl is actually greater than that in group A-2-gh.

The relative efficiency of the groups in five out of eight cases is determined by the records for the subsequent effect of the information. Only in one case (A-1-d), does the immediate effect seem to determine its relative standing.

That verbal information given during the initial trial or trials is more effective than it is when inserted nearer the end of the learning period can be explained by the fact that more errors are usually made during the first few trials than during the later ones, and hence the information has more chance to decrease the error record in the initial trials. Another possible reason for the superiority of

the initial position may be advanced. We may assume that the verbal information produces both a beneficial and a detrimental effect upon the error record. It is likely that the detrimental effect manifests itself to the least extent during the initial trials.

It will be remembered that in table 16 the percentages of saving during the control period decreases at first and then increases. This increase may be explained in this manner: When a subject has traversed the maze for a number of times, most of the errors are eliminated. A few persist for a number of trials, and the tendency to make the same set of errors is partly due to a lack of caution on the part of the subject. When the subject is told at this stage of learnnig that verbal information is to be given, he naturally pays more attention to his work, and this additional effort is responsible for the greater saving in the error records for the comparatively later group of trials during which the information is given.

The fact that the subsequent effect of the information upon the error records is sometimes beneficial and sometimes detrimental needs some explanation, which must differ for the various groups which received different amounts of verbal information. When the information is given during the first trial only, its immediate beneficial effect is very pronounced; but the effect is too transitory to be lasting. Moreover, the subject learns less in one controlled trial than in an uncontrolled one, because the latter permits greater freedom for exploration. This combined influence operated to produce the detrimental effect upon the subsequent error record for group A-1-a. On the other hand, when the controlled trial is shifted down towards the end of the learning period, the subsequent effect becomes more beneficial. This is also a product of two factors; the experience gained previous to the controlled trial plus the immediate beneficial effect make the subsequent effect of the information beneficial. However, group A-1-d is the exception to the rule. The detrimental effect in this case may be due to the operation of chance. In the four two-control groups, the subsequent effect of the information in the first two groups is beneficial. This is accounted for by the fact that the information given during the two trials at the initial positions tends to stay in the

mind of the subject so that he may utilize this knowledge to his advantage in the later trials. When the two controlled trials are moved down to the later positions, the subsequent effect becomes detrimental. The reason is this: When a subject has travelled around the maze for some ten times, he has developed a habit of going into certain *cul de sacs*. Here the verbal information tended to disrupt the old habit with a resultant confusion. Before the correct habit can be established, a considerable number of errors are made. This fact is responsible for the percentage of loss in the subsequent error records for group A-2-gh and A-2-kl.

CHAPTER VI

Effect of Various Distributions of Information

The purpose of this chapter is to study the relative efficiency of various distributions of a given amount of verbal information. In each of the experiments reported in the following pages the A form of verbal information was given in six trials distributed in various ways. In general, the various distributions fell in two main classes. (1) The amount of information interpolated at different positions was varied, while the number of the uncontrolled trials in between was kept constant. (2) The number of the uncontrolled trials between the controlled ones was varied, while the amount of information interpolated at different positions was kept constant.

Five groups of ten subjects each were employed in the experiments. The plan of experimentation is evident from the following schema:

(1) The amount of information given at various positions is varied:
A-6-a..de..hij
A-6-ab..ef..ij
A-6-abc..fg..j

(2) The number of uncontrolled trials between the controlled ones is varied:
A-6-ab..ef..ij
A-6-ab...fg...kl
A-6-ab....gh....mn

In the above schema, 'A' indicates that the A form of verbal information was employed; '6,' the number of trials during which the information was given; 'abcd...,' the positions at which the information was inserted. Thus, A-6-a..de..hij means that the A form of verbal information was given for six trials during the first, fourth, fifth, eight, ninth, and tenth trials.

The results of these groups are compared with those of the normal group of fifteen subjects who learned the maze without

the aid of any information. The comparative data are given in tables 17 and 18. Table 17 gives the gross data for these groups and the percentages of saving due to the information. Table 18 shows the immediate effect of the information for the various positions.

TABLE 17

Effect of Various Distributions of Information

Groups	Trials		Errors		Final Speed	
	No.	Saving	No.	Saving	No.	Saving
N	31.6	.....	206.1	.....	12.68	.....
A-6-a..de..hij	25.3	20.08%	151.4	26.55%	23.00	—81.41%
A-6-ab..ef..ij	21.2	33.03	147.0	28.68	24.40	—92.43
A6-abc..fg..j	21.4	32.41	105.8	48.57	28.10	—121.61
A-6-ab...fg...kl	20.5	35.24	88.3	57.16	28.42	—124.12
A-6-ab....gl.... mn	21.6	31.77	139.0	32.56	25.57	—101.65

TABLE 18

Immediate Effect of Information for Various Positions

Groups	Contr. Trials	Errors	Corresp. Errors in N.	Saving
A-6-a..de..hij	1	22.3	79.07	71.79%
	4-5	20.0	26.26	23.93
	8-9-10	12.8	11.46	—11.69
A-6-ab..ef..ij	1-2	50.2	101.27	48.68
	5-6	18.8	19.28	1.97
	9-10	13.1	5.20	—151.92
A-6-abc..fg..j	1-2-3	66.9	118.27	43.43
	6-7	5.4	19.20	71.87
	10	3.5	3.13	—11.82
A-6-ab...fg...kl	1-2	35.0	101.72	65.59
	6-7	6.8	19.20	64.58
	11-12	3.6	6.86	47.52
A-6-ab....gh....mn	1-2	50.8	101.72	50.05
	7-8	8.6	11.86	27.48
	13-14	4.9	6.26	21.72

The factual results of the experiments reported in this chapter may be summarized as follows:

(1) Verbal information, whatever the way it was distributed,

was universally effective in decreasing the number of trials required to master the maze, the number of errors made in the entire learning period, and the final speed.

(2) On the whole, it affected the records for the final speed most, the error records next and the trial records least.

(3) With one exception, the effect of the information on the trial records for all the groups was practically on a par. This tendency did not exist in the scores for error and final speed.

(4) When the amount of information given at various positions was varied and the number of the uncontrolled trials between positions was constant, the group which received the largest amount of information during the initial trials was in general the most efficient, *i.e.*, A-6-abc..fg..j.

(5) When the number of the uncontrolled trials between the controlled ones was varied, and the amount of information given at various positions was constant, the groups which had the information given during two trials at a time with three uncontrolled trials in between was the most efficient one, *i.e.*, A-6-ab...fg...kl.

(6) When all the different distributions were taken into consideration, the best distribution of the six trials consisted of two controlled trials given at a time with three uncontrolled ones in between.

(7) With one exception, the information given during the initial group of trials exerted the greatest immediate effect upon the error records, while the least effect was invariably produced by the last group (See table 18).

The relative efficiency of the different distributions of a given amount of verbal information is a function of its immediate and subsequent effects. When both the immediate and the subsequent effects are beneficial, the combined influence tends to produce a better record than either one of the two would alone. When one of them is detrimental, it determines the efficiency of the distribution. These facts are shown in table 19, in which the immediate and the subsequent effects are stated in terms of the percentages of saving or loss of each of these groups in respect to the normal group.

Thus, among the groups in which the amount of information

TABLE 19

Immediate and Subsequent Effects of Information

Groups	No. of Errors per Trial in					
	Controlled Period			Uncontrolled Period		
	No.	Cor. No. in N	Saving	No.	Cor. No. in N	Saving
A-6-a..de..hij	9.20	19.46	52.72%	4.9	3.5	—40.00%
A-6-ab..ef..ij	13.71	21.15	35.22	4.2	3.1	—35.49
A-6-abc..fg..j	12.20	23.27	47.57	2.1	2.5	16.00
A-6-ab...fg...kl	7.57	21.13	64.17	2.9	3.1	6.45
A-6-ab....gh....mn	12.40	19.97	37.91	4.8	3.4	—41.18

given at various positions is varied and the number of the intervening uncontrolled trials is constant, group A-6-abc..fg..j is the most efficient, because of the beneficial effects of the information, both immediate and subsequent. Group A-6-ab..ef..ij is more efficient than group A-6-a..de..hij, because the detrimental subsequent effect of the information in the latter is greater than that in the former. Similarly, among the groups in which the number of the uncontrolled trials between the controlled ones is varied and the amount of information given at various positions is kept constant, groups A-6-ab...fg...kl is the most efficient, because both the immediate and the subsequent effects of the information are beneficial. Group A-6-ab..ef..ij is more efficient than group A-6-ab....gh....mn, because the detrimental effect of the information upon the subsequent uncontrolled trials in the former is smaller than that in the latter.

The relative efficiency of these groups may also be measured in terms of the records for the final speed. The most efficient groups are those whose subjects perform the task with much deliberation and hence with lower speed. Among the three groups in which the number of the uncontrolled trials between the controlled ones is varied, group A-6-ab...fg...kl is the most efficient. The subjects in this group travelled slower than those in any other group. Similarly, group A-6-abc..fg..j is the most efficient among those in which the number of the controlled trials is varied at various

positions and it exhibits a comparatively low speed record. When all the controlled groups are taken into consideration, it has been shown that group A-6-ab...fg...kl is the most efficient, and the final speed for this group is lower than that for any other group.

CHAPTER VII

Effect of Information Concerning Types of Error

In this chapter we shall study the effect of giving verbal information concerning the various types of error upon learning the maze. Three groups of fifteen subjects each mastered the maze under different conditions. The members of group X were informed only of each *retracing* error as they made it; those of group Y, of each *cul de sac* error; and those of group A (the same group reported in Chapter III), of *both types* of error. In all cases the information was imparted to the subjects during every trial involved in learning the maze.

The results of these groups were compared with those of the normal group of fifteen subjects who learned the maze without any kind of information concerning their errors. The comparative data are given in table 20 in terms of the total number of trials, the retracing and the *cul de sac* errors, the total number of errors and the final speed.

TABLE 20

Effect on Information Concerning Types of Error

Groups	Trials	Errors			Final Speed
		Retracing	Cul de sac	Total	
N	31.66	67.4	138.7	206.1	12.68
X	37.80	46.1	140.2	186.3	21.32
Y	23.07	62.1	96.2	158.3	21.15
A	22.27	28.8	74.4	103.2	21.81

The factual results of these experiments may be summarized as follows:

(1) Verbal information operated to decrease the records for the total number of errors made during the entire period of learning and to increase the records for the final speed in all cases. It decreased the total number of trials required to master the maze in all but one case.

(2) When the subjects were informed of one type of error

only (be it retracing or *cul de sac*), they made poorer records for the total number of trials, the retracing and the *cul de sac* errors, and the total number of errors than did those who received information concerning both types of error. The records for the final speed are practically on a par in the two cases.

(3) Information concerning the *cul de sac* errors produced a more beneficial effect upon learning the maze than did that concerning the retracing errors. The former tended to decrease the total number of trials, while the latter exhibited the opposite tendency.

(4) Information concerning the retracing errors cut down the retracing errors but not the *cul de sac* errors, while that concerning the *cul de sac* errors decreased the total number of *cul de sac* errors but not the retracing errors.

That the results of group A are superior to those of either group X or group Y is too obvious to require any explanation. So also is the fact that the error records for groups A, X and Y are superior to that for the normal group.

The superiority of the trial records for the groups A and Y over that for the normal group may be accounted for by the low error records for the former groups.

The fact that the trial record for group X is inferior to that for the normal group needs explanation. Several possibilities may be advanced:

(1) The inferior trial record for group X may be due to the operation of chance. But this is hardly probable. In table 21 the distribution of the individual trial records for each group is giv-

TABLE 21

Distribution of Individual Trials

Groups	Individual Trial Records														
N	17	18	19	24	24	26	29	*29*	37	38	39	39	39	45	62
X	20	*22*	23	24	25	31	32	*33*	36	45	49	49	52	61	65
Y	10	12	15	16	16	18	21	*22*	23	23	24	24	32	41	49
A	8	9	12	13	17	18	19	*20*	22	25	26	28	30	41	46

en. It will be seen that group X has just as consistent a distribution of the individual trial records as that of any one of the other three groups. It starts higher and ends higher than any other one; also it has the highest median (33) among the four. The high trial record, then, is not due to any one unusually large individual record.

(2) The inferiority of the trial record for group X may be due to a change of attitude on the part of the experimenter toward the subjects. This is not likely the case, because groups X and Y were run simultaneously. Were there such a change of attitude on the part of the experimenter, it would have affected the results of group X as well as those of group Y.

(3) A third possible explanation may be given in terms of the attitude of the subjects. In group X the subjects soon developed the habit of relying upon the experimenter for the information concerning the retracing error. This attitude of dependence on the part of the subjects actually delayed the complete elimination of the retracing errors. Thus, in the normal group the habit of the subjects of retracing the correct pathway was dislodged on the average by the end of the eighteenth trial, while the same habit persisted in group X to the end of the twenty-second one. Inasmuch as the elimination of the retracing errors was usually completed long before that of the *cul de sac* errors, this delay in completing the elimination of the retracing errors also postponed the complete elimination of the *cul de sac* errors. Hence, the trial record was prolonged.

(4) Since in group X the attention of the subjects was called to the retracing errors alone, naturally they were more cautious about them than about the *cul de sac* errors. This insufficiency of attention given to the latter was responsible not only for the delayed final elimination of the *cul de sac* errors but also for their large number. Thus, the number of the *cul de sac* errors in the normal group was 138.7, while that in group X was 140.2. This high record for the *cul de sac* errors together with the consequent postponement of their final elimination may account for the high trial record.

(5) The knowledge obtained from the information concerning

the retracing errors is much less definite than that of the *cul de sac* error. Information concerning the retracing error often gives rise to confusion on the part of the subjects resulting in uncertainty in their work. Such confusion not only favors the rise of errors but also gives occasion for them to persist. Both these factors tend to produce a high trial record.

Whatever the explanation one may adopt, the fact remains that information concerning the retracing errors when given alone tends to prolong the trial record.

It is also significant to note that information concerning the *cul de sac* errors is more beneficial in learning the maze than that concerning the retracing errors. The former exerts a beneficial influence on both the trial and error records, while the latter proves detrimental to the trial record and beneficial to the error record only to a very limited extent.

CHAPTER VIII

Instructional vs. Informational Methods of Tuition

In the previous chapters we have studied the effect of two different methods of tuition upon maze learning: (1) The Instructional method by means of which the subject is guided over the correct pathway and all possibility of errors is prevented and (2) the Informational method in which the subject is informed of each error as it is made. The influence of the former was studied in Chapter II and that of the latter in Chapters III-VI inclusive.

This chapter is concerned with a comparison of the relative efficiency of these two forms of tuition in acquiring an act of skill. Only three groups were given comparable amounts of tuition by the two methods, viz., those to whom the tuition was given for the first trial, the first two trials and the initial eight trials. The comparative data presented in table 22 were calculated in terms of the superiority of the method of Instruction. For example, group D-2-ab which was given instructions during the first two trials made a better record than did group A-2-ab which was given a similar amount of Information. Group D-2-ab was superior to group A-2-ab by 6.69% in trial, 55.74% and 45.38% respectively in retracing and *cul de sac* errors, and 66.62% in the number of errors per trial. It was inferior to group A-2-ab by 18.63% in final speed.

TABLE 22

Instructional vs. Informational Methods of Tuition

Groups	Trials	Errors		Errors per Trial	Final Speed
		Retrac.	Blind		
D-1-a vs. A-1-a	—4.78%	22.95%	27.14%	41.82%	—27.23%
D-2-ab vs. A-2-ab	6.69	55.74	45.38	66.62	—18.63
D-8-a..h vs. A-8-a..h	35.46	58.73	61.33	75.89	— 2.91

These data justify the following conclusions:

(1) With one exception, the Instructional Method of tuition

is the more effective upon the scores for trials, the two kinds of error, the average number of errors per trial and the final speed.

(2) Its relative efficiency increases with the amount of instruction given.

The superiority of the instructional over the informational method of tuition in the trial and error records may be explained in several ways: (1) The absence of error when the instructional method was employed—In the groups in which the instructional method was employed, the subjects had no chance to make any error during the controlled trials. In those to whom the information was given during a given number of trials, the subjects did make a number of errors during the controlled period. This difference operates to decrease the error for the instructional method. (2) The kind of knowledge of the maze—Verbal instructions give the subjects a knowledge of the correct pathway, while verbal information aids them in the discovery of the errors. The former is a case of positive guidance, while the latter is one of negative assistance. It is a common sense pedagogical principle that positive instruction is always more effective than negative assistance.

The fact that the instructional groups exhibited a lower speed record than the informational groups can be explained in terms of the degree of caution on the part of the subjects. The instructional method seemed to induce within the subjects a more cautious attitude than did the informational method. With the former method the subjects acquired a knowledge of the correct pathway but not of the *cul de sacs*. Consequently, conscious of this deficiency, they worked very carefully and hence slowly. With the latter method, the subjects acquired a knowledge of both. With a certain degree of familiarity of the paths of the maze, they travelled over them with comparatively less hesitancy and higher speed than those who worked with the former method.

CHAPTER IX

Incidental Observations

The incidental observations reported in this chapter are the by-products in the general inquiry concerning the influences of tuition upon learning a stylus maze. These observations will be treated in the most summary fashion under the following topics: (A) Individual differences, (B) Sex differences, and (C) Order of elimination of the *cul de sac* errors.

(A) Individual Differences—Under this topic there will be studied individual differences (1) as indicated by the various criteria of learning, (2) in the order of error elimination, and (3) in the modes of attacking the problems.

(1) Individual differences as indicated by the various criteria of learning—Individual differences within one group are compared with those in the other groups with reference to their records for trial, error, and final speed. These comparative data are given in table 23, in which each value represents the extreme range of individual differences within any one group expressed in terms of the percentage of the poorest over the best. For example, the poorest record in the normal group is worse than the best by 360% in trial, 420% in error and 150% in final speed.

The facts in this table justify the following conclusions:

(a) In a comparison of the range of individual differences within each of the twenty-one groups with that of the normal group, thirteen are found to show greater variability in trials, seventeen in errors, and twenty-one in final speed. Tuition, in general, increased the extreme range of individual differences within a group.

(b) With the exception of the records for the final speed, the range of individual differences within the group is on the whole smaller in the D groups (Instructional Method) than in the A groups (Informational Method).

(c) In general, individuals differ most widely in errors, next in trials, and least in final speed.

TABLE 23

Individual Differences as Indicated by Various Criteria of Learning

Groups	Subjects	Trials	Errors	Final Speed
N	15	360%	420%	150%
D-1-a	10	250	272	1070
D-2-ab	10	520	580	320
D-4-a—d	10	410		610
D-8-a..h	10	330	393	350
D-16-a..p	10	210	640	520
A	15	570	1540	450
A-1-a	10	510	1130	270
A-2-ab	15	400	1640	290
A-8-a..h	15	270	1510	330
A-12-a..l	10	460	2330	220
A-1-b	10	340	1330	220
A-1-d	15	420	1790	290
A-1-f	15	600	2520	610
A-2-cd	15	690	2320	270
A-2-gh	10	600	470	420
A-2-kl	10	430	420	190
A-6a..de..hij	10	430	550	390
A-6-ab..ef..ij	10	310	730	310
A-6-abc..fg..j	10	180	300	370
A-6-ab...fg...kl	10	220	510	310
A-6-ab....gh....mn	10	530	1220	160

(2) Individual differences in error elimination—An examination of 86 records shows that various *cul de sacs* attracted individuals differently. The following table gives the *cul de sacs* eliminated first and last (as indicated by the figures in the first row). The figure opposite each *cul de sac* indicates the number of persons who eliminated that *cul de sac* error in the same temporal order. The asterisk shows the greatest number of persons who eliminated a *cul de sac* error in the same order.

From this table it is evident that (1) individuals differ much more greatly in the *cul de sac* errors which are eliminated first than those eliminated last, and (2) the tendency to eliminate the *cul de sacs* G and E last is very marked.

(3) Individual differences in the mode of attacking the problem—As observed individuals seem to have different methods of learning the maze. The following are typical: (a) The maze pattern was visualized in the first few trials and the visual image of

TABLE 24

Showing Cul-de-sacs Eliminated first and last

Cul de sacs		1st	2nd	15th	16th
Goal	E'†	5	1	11	7
End	F'	11	10		1
	G'	16	7		
	H'	17	5		
	H	7	16*	2	2
	A'	21*	2		1
	B'	4	3	10	14
	C'	11	9		
	G	1	7	18*	24*
	F	10	13	2	
	E	1	3	30*	21*
	D'	9	6	13	2
	D	10	12	3	2
	C	18	15*		
Entr.	B	14	14		
End	A	22*	13		

†E'=*Cul de sac* on the other side of E; F', the other side of F; etc.

the pattern was employed as a guide in the subsequent ones. (b) The arm movements employed in learning were remembered. Some of the subjects discovered that the movements for the two halves of the maze were almost identical and that those employed in the center were of the stair-case fashion. Some mastered the maze (c) by being able to judge the distances between the sections of the correct path; others (d) simply remembered the exact direction to go to the goal end. (e) Several went through the maze correctly by being able to remember against which side of the groove to lean the stylus. (f) A number of them were able to keep the stylus in the right groove by remembering the number of sections traversed. No attempt has been made to correlate the modes of attack and the efficiency of the work. It is probably a matter of individual preference. A method employed advantageously by one may be adopted by the other to his utter disadvantage.

(B) Sex differences—The facts about sex differences are summarized in the following table in which the figures in the brackets indicate the number of cases which goes to make up the average.

TABLE 25

Sex Differences

Criteria	N		A		D	
	M (8)	F (7)	M (120)	F (70)	M (36)	F (14)
Trial	31.75	31.57	117.59	25.67	22.42	29.07
Error	176.59	226.71	21.83	144.65	36.61	75.64
Fin. Speed	11.50	13.37	21.61	22.31	24.40	25.47

On the whole women made a poorer record than men. The greatest difference is in the error record and the smallest in the record for the final speed. A greater sex difference exists in the D-form than in the A-form of tuition. These differences, however, may be due to the comparatively small number of records for women.

(C) Order of elimination of the *cul de sac* errors—In the study of the individual differences in the order of elimination of the *cul de sac* errors, we were impressed by the fact that there was no definite relationship between the spatial order of the *cul de sacs* and the temporal order of their elimination so far as the four cases there considered were concerned (see table 24). In order to substantiate this statement 86 records were studied with reference to the order of elimination of all the sixteen *cul de sac* errors. The results are shown in table 26, in which each figure represents the average of 86 records.

TABLE 26

Relationship between Spatial Order of Cul de Sacs and Temporal Order of Their Elimination

Order fr. Entrance	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Blind Alley	A	B	C	D	D'	E	F	G	C'	B'	A'	H	H'	G'	F'	E'
Order of Eliminat.	3	7	1	9	13	15	5	16	6	14	10	11	2	4	8	12

Our results do not support the contention of a backward elimination of the *cul de sac* errors; nor do they give evidence for any current theory of error elimination in the maze. On the contrary, they seem to indicate that the temporal order of the elimination of the *cul de sac* errors is a function of the nature or the peculiar

position of the *cul de sacs*. *Cul de sacs* C, A, G′ and H′ (see Fig. 1) were eliminated first because they were more or less out of the way with respect to the correct pathway. *Cul de sacs* G, E, B′ and E′ were eliminated last, because they occupied peculiarly attractive positions. *Cul de sac* E is located at the end of a comparatively short runway perpendicular to a very long section of the correct pathway. On emerging from this long section, the subjects usually over-estimated the distance of this short runway ending in *cul de sac* E. Hence, instead of going into the opening to the correct pathway, which was a little distance from E, they usually passed over this opening and made an error at E. A similar explanation can be given for the frequent entrance into the *cul de sacs* G, B′ and E′.

Another interesting fact may be noted in connection with the study of the temporal order of elimination of the *cul de sac* errors. The initial and final errors were eliminated first. This seems to follow the general law in memory work, that the material at the two ends of a series is always mastered first.

CHAPTER X

Summary and Conclusions

In this study of the influence of tuition upon learning a stylus maze, two forms of tuition were employed; namely, the method of verbal instruction and the method of verbal information.

Without a single exception, tuition operated to decrease the number of errors made during the entire period of learning and the average final speed employed to travel through the correct pathway. It operated to decrease the total number of trials required to master the maze in twenty-one out of twenty-three cases. The decrease of the error records due to the operation of tuition was obvious. That tuition operated to decrease the final speed was explained by the fact that it induced in the subjects the attitude of caution, which meant slow movement. This attitude of caution induced by the tuition seemed to be the reason for the effectiveness of tuition in learning.

Without exception tuition affected the records for the final speed most, the error records next, and the trial records least.

The effect of tuition on the retracing errors was invariably greater than that on the *cul de sac* errors.

Of the two forms of tuition employed in this investigation, the instructional method proved to be more effective than the informational method.

Of the three forms of verbal information employed, method C (naming each error by the experimenter after it was made) was slightly more efficient than methods A and B. The differences between them were too small to be significant. Method A was, however, chosen for the various investigations of the effect of the verbal information upon learning the maze, because it was easily administered.

In the study of the effect of various amounts of tuition upon learning the maze, it was brought out that the effectiveness at first increased and then decreased, as the number of the controlled trials was increased. This was true for both the methods of instruction and that of information. In the former the number of

controlled trials that produced the optimal effectiveness was four, while in the latter it was eight. The reason for the increase of the efficacy of tuition at first is self-evident. The decrease of its effectiveness after the optimal number of controlled trials was reached has been explained in terms of the amount of tuition given in addition to the optimal amount. This additional amount was considered to be superfluous. Superfluous trials necessarily increase the trial and error records. Any excessive amount of tuition is apt to develop either an attitude of over-confidence or a habit of dependence upon the experimenter, both of which are responsible for the high trial and error records.

When a given amount of verbal information was imparted at various positions, the initial position was found to be the most effective. This is true irrespective of the amount of information imparted to the subjects. The relative value of the various positions seems to be a function of the combined influence of the immediate and the subsequent effects of the information upon the error records. The maximal effectiveness of the information at the initial position was explained in two ways: (1) The information gave more chance to decrease the errors, since more errors were usually made during the initial trials than during the subsequent ones. (2) It was assumed that the information, capable of producing both beneficial and detrimental effects upon the error records, tended to exert the greatest beneficial and the least detrimental influence during the initial trials.

When the verbal information was given during six trials distributed in various ways, the best distribution was found to consist of two controlled trials given at a time with three uncontrolled ones in between.

When the subjects were informed of one type of error only (be it retracing or *cul de sac*), they made poorer records for the total number of trials, the retracing and the *cul de sac* errors, and the total number of errors than did those who received information concerning both types of error. The records for the final speed are practically on a par in the two cases.

Information concerning the *cul de sac* errors produced a more beneficial effect upon learning the maze than did that concerning

the retracing errors. The former exerted a beneficial influence on both the trial and error records, while the latter proved detrimental to the trial record and beneficial to the error record only to a very limited extent.

The superiority of the instructional over the informational method of tuition on the trial and error records has been explained in terms of (1) the absence of errors when the former method was employed, and (2) the nature of the tuition, *i.e.*, positive guidance *vs.* negative assistance, the former being naturally more effective than the latter. The superiority of the informational groups over the instructional groups in the scores for the final speed was explained in terms of the degree of caution induced by the two forms of tuition. The instructional form induced within the subjects a more cautious attitude than the informational form, because the former gave them a knowledge of the correct pathway only, while the latter enabled them to obtain this and also a general knowledge of the *cul de sacs* entered.

Marked individual differences existed in all the experiments reported in this investigation. In general, individuals differ most widely in errors, next in trials and least in final speed.

Sex differences in the ability to learn the maze were not very pronounced. On the whole, women made a slightly poorer record than men.

There was no definite relationship between the spatial order of the *cul de sacs* and the temporal order of their elimination. The temporal order of elimination of the *cul de sac* errors seems to be a function of the peculiar position of the *cul de sacs* in the maze. In general, it was found that the *cul de sacs* at both the entrance and the goal ends were eliminated first.

VOL. 34
NO. 2

PSYCHOLOGICAL REVIEW PUBLICATIONS

WHOLE NO. 155
1925

Psychological Monographs

EDITED BY

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Splitting the Mind:
An Experimental Study of Normal Men

BY

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PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.
AND ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.);
Paris (16, rue de Condé)

If a dedication to such a monograph were in order, this would be inscribed to the chief observers of these experiments,

J. L. B.,
G. E. H.,
H. W. L.,

upon whose careful work this book depends, and whose abundant help is gratefully acknowledged.

INTRODUCTORY NOTE

It is somewhat unusual to present full protocols in experiments under hypnosis. In the present instance it has seemed justifiable on account of the critical nature of the problem whose solution is here sought. In drawing conclusions the present experimenter has not wittingly depended on any other data than those here spread out in full before the reader. If these do not warrant the conclusion, nothing else will be whisked in surreptitiously by way of support. Should he, then, doubt the offered interpretation, he will have at hand the entire body of data with which his preferred interpretation will have to wrestle.

ACKNOWLEDGMENT

The cost of printing this monograph has been defrayed by Bowdoin College from a publication fund given by Dwight W. Morrow.

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CHRONOLOGICAL ORDER OF EXPERIMENTS

Date	*Observer*	*Reference Symbol*
Jan. 18, 1920	G. E. H.	I
Jan. 19, 1920	G. E. H.	1
Jan. 24, 1920	G. E. H.	X 1
Jan. 24, 1920	J. L. B.	X 2
Jan. 31, 1920	G. E. H.	2
Jan. 31, 1920	G. E. H.	X 3
April 13, 1920	G. E. H.	N
April 13, 1920	G. E. H.	3
April 13, 1920	G. E. H.	A
April 15, 1920	G. E. H.	X 4
April 15, 1920	G. E. H.	Y
April 15, 1920	G. E. H.	K
April 20, 1920	J. L. B.	II
April 28, 1920	G. E. H.	III
April 29, 1920	H. W. L.	L
April 30, 1920	H. W. L.	IV
April 30, 1920	H. W. L.	4
April 30, 1920	G. E. H.	V
May 4, 1920	P. J.	M
May 4, 1920	G. E. H.	5
May 18, 1920	P. J.	O
May 20, 1920	G. E. H.	P
May 20, 1920	H. W. L.	6
May 21, 1920	F. W. A.	C
May 21, 1920	H. W. L.	Q
May 27, 1920	G. E. H.	7
May 27, 1920	G. E. H.	8
April 26, 1921	G. E. H.	9
April 28, 1921	G. E. H.	X 5
May 5, 1921	J. L. B.	B
May 5, 1921	J. L. B.	10
May 10, 1921	G. E. H.	Z 1
May 10, 1921	J. L. B.	X 6
May 10, 1921	J. L. B.	Z 2
May 18, 1921	J. L. B.	11
May 18, 1921	G. E. H.	12
June 10, 1921	G. E. H.	13

PART I

INTRODUCTION

1. The Problem and the Standard of Proof

By splitting the mind is meant, for the purposes of this study, the dissociation of an individual's mental states into two or more groups or systems, that function separately but at the same time. It has been common to speak of "split-off" states, a phrase which tacitly assumes the superiority in some sense of the system from which the splitting has taken place. The problem of the existence of the split-off group, as something still psychic and not merely neural, has been much to the fore during the last twenty years. Morton Prince[1] first gave to such a persistent psychic system the name of co-consciousness. Speaking abstractly, one means by this term the fact of two or more mental states or systems operating separately in dependence on the one human body; or, concretely, any or all of such groups other than the "primary" group, or "personality." This last term means, (a) the group that controls most of the voluntary muscles, (b) the group that controls the muscles of expression for the head, (c) the group that includes the most immediately useful memories, or (d) some combination of the foregoing. Two facts make the continuance of the distinction between "primary" and "secondary" forced and probably unfruitful, viz., the quantitative variations in the content of these co-conscious groups as well as of the "primary," and the discovery in mental disease that all, even the "primary," were fragments of a whole which together they all constituted. This distinction might be revived if, in the integration of the fragments into a complete personality, there be any outstanding group incapable of such integration. Such apparently is the group called "Sally" in the case of Miss Beauchamp.[2]

[1] Prince, Morton. *The Unconscious*, p. 14.
[2] Prince, Morton. *The Dissociation of a Personality.*

The literature in this field seems to be divisible into the following parts:

(a) Attempts to explain major happenings in abnormal minds and minor happenings in the normal by the assumption of co-consciousness.

(b) Controversies over the validity of this hypothesis as against that of "unconscious cerebration."

(c) Experimental demonstration of co-consciousness in abnormal minds.

(d) Experimental development of means for revealing the existence and content of a co-consciousness.

Of the foregoing (c) occupies of course the fundamental position, but must, at every step, be mindful of (b), since the existence of consciousness, objectively acknowledged, is always, whether for professional experimenter or layman, a matter of interpreting observed facts.

The foregoing classification of literature is convenient for comprehending the problem. Published work, of course, now and again cuts across this arrangement.

One need not labor over the thesis that a standard for acknowledging the existence of consciousness in any concrete instance is fundamental to proper experimental investigations under (c). In fixing upon such a standard, proper scientific method does not seem to demand that one should require of such a standard either that it constitute in itself a denial of the thing investigated, and so the inquiry abort, nor, in the case of abnormal phenomena, require a standard which we neither ask nor need in the normal. The proponents of "cerebration" seem to fall into the first of the foregoing errors. Their interpretation, applying equally well to all alleged mental phenomena, normal and abnormal, frequent and rare, would, if given its logical scope, negate all objective psychic facts whatever. For indeed in all recognized instances of embodied, human, mental life we acknowledge cerebration, or at least nerve function. We must rather find and employ the standard actually current among mankind for distinguishing matter and its operations from "conscious fellow creature," unless this current, real standard can be shown to be scientifically

insufficient. Science must make precise for its own ends this standard of the man of the street, which he has gradually acquired, not logically derived; which he has easily used in most cases, but rarely formulated with ease, if at all. Even in its use he is occasionally nonplussed. Mental disease, ouija boards, spiritistic phenomena, and the like bring him to a pause. Then comes the expert.

Prince has felt the need of this formulation; and he has acknowledged such a standard, in greater part, in the arrangement of his experiments for the demonstration of co-consciousness. His reference to it is explicit, though he does not set it in the forefront of his exposition.

This standard must meet two demands: for a criterion of consciousness, for a criterion of dissociated consciousness. These demands correspond respectively to the questions: Are not the phenomena unconscious? If not, are they not the work of the one usual consciousness, acknowledged by all of us in every man?

Conformably to these demands, the standard may be formulated as follows:

(1) The hypothetical co-consciousness must reveal itself in a given individual by unlearned, noninstinctive adaptation to a situation (intelligence test).

(2) The evidence for (1) must be objective, available at the time of its alleged existence, not merely the possible implication of a later fact (objective evidence test).

(3) The adaptation must leave the individual in ignorance of that event at the time of it. The evidence for this must be either the observer's own assertion, or the fact that he was at the time engaged in something that ordinarily cannot be done without full attention; or, best of all, both of these (dissociation test).

(4) The observer must later report this act of adaptation, though meanwhile without access to any source of knowledge other than the original occurrence (positive memory test).

(5) He must be able to recall also the fact of dissociation, viz., that at the time it existed he was not aware of it (negative memory test).

(6) No stricter logical demands must be made on the evidence

than are actually acceptable and sufficient in dealing with similar facts elsewhere in life, especially no demands which, by their character, nullify the very possibility of offering any evidence (proper proof test).

Of these several tests (4) and (5) may be omitted without really impairing the proof, though their successful application gives to the proof a fullness that is an especially satisfactory confirmation.

Let me state once more the meaning of this standard in terms of a situation and a procedure.

Give a man a plan for performing a fairly complex mental task. At the time of performance—and not till then—give him the data on which the plan is to be executed. Let him perform the task. At the same time, test his ability to report on what he is doing. Then remove him from the situation and give him a chance to report it without aid from any source except the original experience. If he succeeds in performing the task and later recalls it with no outside aid, we may say in effect: The intelligent character of the original act is such as we know in ourselves, and ordinarily recognize in others, only as a conscious act; and, moreover, he must have been conscious *then* to *remember now*. If, in addition, at the time of performance, he made evident that in some sense he was unaware of his act, we have the right to say descriptively, that at that time he was in some sense doubly conscious, not integratedly conscious; that his mental states formed at least two dissociated wholes.

My contentions are that the standard here formulated is both real and scientifically fruitful. If anyone doubts the first of these, the mode of opening up the attack is the one usual in an alleged matter of fact. If anyone doubts the second contention, he is asked to note the clearness with which, in its terms, the mass of experiences reported in these pages can be interpreted, and the fruitful therapeutics following upon its use in the sphere of abnormal mental life.

2. Experiments and Methods of the Past

The experimental means for demonstrating co-consciousness that have thus been used are hypnosis with automatic writing;[1] automatic writing alone;[2] the psycho-galvanic reflex;[3] [4] free association;[5] and image-formation.[6] Of these none but the first two seems suitable to furnish independent proof of the fact in question, by the standard for proof which has been stated above. Conceivably, by use of hypnosis, the memory test (Canon 4 above) might be applicable to all, and, in the case of hysterical dissociation, even without hypnosis. I am not aware, however, that the memory test has actually been applied with any of these methods except the first two. The results so far obtained, though, by these other methods seem to have confirmatory, rather than independently probative, force. Those by the image-formation method, indeed, are, in their psychic abundance and variety, as found, an affair of "primary" consciousness, and only by interpretation are assigned causally to a subconsciousness of correspondingly varied content.

Relying upon our standard of proof, Prince[1] [2] has, it seems, experimentally demonstrated the existence of co-consciousness in two abnormal individuals. In addition, Prince and Peterson, working with the psycho-galvanic reflex, on one of these same individuals who was without conscious emotion, have obtained curves like those obtained from normal individuals with conscious emotions. They *infer,* therefore, co-conscious emotion in the abnormal case. This experiment has, however, merely confirmatory value for proofs otherwise obtained, since, by itself,

[1] Prince, Morton. Experiments to Determine Co-conscious (Subconscious) Ideation. *J. Abn. Psych.,* 3 (1908–9), p. 33.

[2] Prince, M. An Experimental Study of the Mechanism of Hallucinations. *Brit. J. Psych.* (Med. Sec.), 2 (1922), p. 165.

[3] Prince, M., and Peterson, F. Experiments in Psychogalvanic Reaction from Co-conscious (Subconscious) Ideas in a Case of Multiple Personality. *J. Abn. Psych.,* 3 (1908–9), p. 114.

[4] Jung, C. G. On Psycho-physical Relations of the Associative Experiment. *J. Abn. Psych.,* 1 (1906–7), p. 247.

[5] Jung, C. G. The Associative Method. *Am. J. Psych.,* 21 (1910), p. 219.

[6] Martin, L. J. An Experimental Contribution to the Investigation of the Subconscious. *Psych. Rev.,* 22 (1915), p. 251.

it does not inevitably require a larger hypothesis than that of "unconscious cerebration."

Let me here show the probative quality of Prince's demonstration,[1] as I conceive it, since this has an important bearing on my own experiments.

Exp. I. Hysterical subject B A, showing multiple personality, of which one personality is called A and the other B. A has no knowledge of B, but B is completely aware of A. B hypnotized is called b. B has no recollection of b. B is given the problem to calculate the number of seconds by the clock between two fixed points in time, which will be shown her when A comes again, the answer to be written automatically while A is present. A comes and is shown a paper containing the numbers 1.43 and 3.39 written one above the other at the top of a sheet of foolscap. The hand thereupon, wrote thus—

"1.43 to 3.39 would be two hours less than" (sentence unfinished).

$$\begin{array}{r} 114 \\ 60 \\ \hline 6840 \quad " \end{array}$$

A meanwhile was conversing and did not look at the paper while the hand wrote. The multiplication, be it observed, is correct, though the elapsed minutes were wrongly calculated.

Later B (and b) reported the event. This fact is not stated but is properly to be inferred from the author's statement that "B and b later explained that when doing a calculation co-consciously," etc. (p. 40). A more serious omission in the published account is the absence of any reference to the question whether, meanwhile, B had had access to any other source of knowledge of the original event than that event in actual process of occurring. Thus the memory part of the standard for acknowledging co-consciousness seems not to have been met quite scrupulously. Nor did the author state, so far as I see,

[1] Prince, Morton. Experiments to Determine Co-conscious (Subconscious) Ideation. *J. Abn. Psych.*, 3 (1908–9), p. 33.

in this the first crucial experiment he had reported, the evidence that A did not know the content of the automatic episode. He might reply that it is to be found scattered in abundance through reports of similar cases, and is well enough known to investigators. But in the report of a critical experiment meant to solve a much controverted question, nothing logically essential should be omitted. Further, the record does not disclose whether in this experiment the writing was spontaneous or due to a post-hypnotic suggestion, nor to what extent, if at all, hypnosis was a feature of the procedure. A possibly meticulous criticism is here a compliment to the only crucial experiments in the field which I have found in print.

As to other experiments of this sort made by him, he says:

"A number of similar experiments in which the calculations were written automatically were made. The results were substantially the same, the multiplication being always correct, though the elapsed minutes were wrong" (p. 40). The author does not state whether these were made on the same person or on others.

Exp. II, on the same individual as Exp. I: B was taught some dozen characters of a system of shorthand invented by the experimenter and never seen before by B A. As soon as these were memorized the experimenter changed B to A. The experimenter then wrote a brief sentence involving the learned characters and showed it to A, "to whom it meant nothing" (p. 40). The hand promptly wrote automatically a correct translation.

Again the author fails to state how he tested the dissociation during the writing; and he omits the memory part of the test. But conformity to Canons 1–3 of our standard seems to give to this experiment, as to the first one recounted, probative force.

The remaining experiments recorded in Prince's article, including those on a second abnormal individual (Miss Beauchamp), I do not here report, as they do not seem to satisfy the requirements of the standard.

Turning now to Prince's second article,[1] with its report of experiments on a second abnormal individual, we note that his purpose was to prove that the origin of certain visual and

[1] See footnote [2], p. 5.

auditory hallucinations, experimentally induced, was in subconscious (co-conscious) psychic states (p. 167). His experimental logic is again explicit. "The following procedure was devised: (a) to induce experimentally subconscious processes; (b) to 'tap' the subconscious process while in progress and obtain physical records of it; (c) if any hallucinations occurred synchronously to obtain a detailed description of the same; (d) to correlate by comparison if possible the imagery of the hallucination with the ideas expressed in the written record of the subconscious process; and (e) to obtain immediate evidence by subconscious introspection of the relation, if any, between the elements of the subconscious process and the imagery of the hallucination and the mechanism of the same" (p. 168). These seem to be Canon 2 and, by implication, Canons 3 and 4 of our standard. The results of the experiments show that Prince obtained from his abnormal subject automatic writing purporting to report thoughts and images about data formerly experienced by her. Both the alleged mental process and the writing were in fulfillment of a plan imposed by the experimenter. In various experiments the plans were severally (a) to write automatically an account of some episode (not further specified) in her life; (b) to make up subconsciously and write automatically a story based on materials belonging to her one-time secondary personality; (c) to make up subconsciously and write automatically a story on any subject; (d) to write automatically some memory of an anxious kind; (e) to gaze into a crystal and write automatically any subconscious thoughts occurring during the crystal visions; (f) to select subconsciously and write automatically some sentence (not further specified) which was to appear thereupon consciously as a verbal auditory hallucination.

These directions were given without hypnosis and, presumably, by word of mouth. Both consciousness and alleged subconsciousness thus knew the plan; but consciousness did not know whether or how it was accomplished. These experiments were all successfully carried out; and at the close of those of types (a)–(c) above, the observer by request wrote automatically what purported to be an introspective account of just preceding subcon-

scious experiences. The " intelligent " character of the processes in question consists in recalling old data, inventing stories, inventing (or recalling) a sentence, and " thinking "—all according to plans accepted from the experimenter.

The successful application of Canons 1–3 in these experiments seems to me to offer evidence for co-consciousness so significant as to be probative, though the data on which the alleged psychic processes operated had all been known previously to the observer. Prince's report implies the successful application of the positive memory test (Canon 4), in his report of the content of the script and in his express reference to " a carefully worded questionnaire . . . care being taken to suggest no leads or theories " (p. 187); but as the protocol is not offered for examination we cannot form an independent judgment. Moreover, Prince was not primarily concerned with the application of Canon 4, but with obtaining evidence for subconscious knowledge of a causal relation between events in subconsciousness and hallucinations in consciousness.

Here, then, we seem to have a small amount of adequate evidence, from two abnormal individuals, to prove the existence of co-consciousness. Can it be proved from evidence obtained from normal individuals? This was the object of my experiments. That object is, not to show the permanent existence nor the occasional, natural occurrence of co-consciousness in a normal individual, but that it can be artificially produced in such a one—all this in contrast with the occasional, or possibly permanent, natural occurrence in certain abnormal individuals, hitherto alone the concern of scientific inquiry.

3. Special Conditions and Method of These Experiments

The problem was brought into the laboratory in a variety of ways, each intended to reveal the existence and complexity of co-consciousness, if such there be. In all, the experimental method adopted was that of hypnosis and automatic writing—hypnosis to produce the necessary dissociation, automatic writing to furnish a means of communication with any discoverable co-consciousness. All the individuals whose experimental results

are here recorded—the " observers "—were able to develop fairly deep states of hypnosis. The experiments fell naturally into two groups. The first is that of strictly probative experiments—those which seem to demonstrate conclusively the artificial production of co-consciousness in normal persons. These experiments meet the demands of the standard given on an earlier page. This required demonstration was yielded by three observers. While the reader is referred to the full exposition to come, a cursory anticipation may not be amiss to him here.

A plan of action was given the observer in hypnosis (Hypnotic Stage 1 or Hyp. 1). It required for execution data and a special treatment of them. The data were often numbers; the treatment often that of such mathematical processes as addition, subtraction, multiplication, and division; or the performance of a task according to the interpretation of data by a code agreed upon.

The sources of the data were variously contrived to keep them unguessable. Sometimes they were given in Hypnotic Stage 1 (Hyp. 1), *e.g.,* a number, while the remainder was to be found in the Interim Stage (*i.e.,* the stage between two hypnoses—Int.) according to the plan given in Hypnotic Stage 1 (Hyp. 1), *e.g.,* the number of shelves in a particular bookcase out of the many in the experimenting room. Or the entire data might be given in the Interim Stage (Int.)—*e.g.,* numbers written unobtrusively on the corners of a sheet of paper which was being used by the observer for some task both prescribed and executed during this stage (Prince's Method); or, again, one number might be the number of the page which the observer, during the Interim Stage, was reading at the moment when some sign was given, and the other number might be the number of taps made unobtrusively by the experimenter. The possible variations are obviously many.

The precise treatment to be given by the observer to the data was sometimes made to depend on some special character of the numbers found, *e.g.,* their color, according, of course, to a code given in Hypnotic Stage 1 (Hyp. 1).

Sometimes a continuous and direct exchange of communications could be maintained between the writing hand and the experimenter, of the meaning of whose talk, if not the fact of it,

the observer seemed unaware, ignoring him except as he was referred to by the recorder.

The evidence for the performance was given sometimes by automatic writing in the same Interim Stage (Int.); sometimes vocally, just after the induction of a second hypnosis (Hypnotic Stage 2 [Hyp. 2]).

It will be noted that the psychical functions of perception, controlled association, and expression are involved in the foregoing phenomena.

Tests in the Interim Stage (Int.) showed ignorance of data, plan, and execution; Hypnotic Stage 2 (Hyp. 2), on the contrary, showed full knowledge, when, meanwhile, no source of such knowledge, other than the original experience, was open; and sometimes this was retained in the Post-hypnotic Stage (Post-hyp.).

Into a second group fall experiments that are confirmatory rather than strictly probative, in the matter at issue, viz., co-consciousness. These were for the greater part planned along the foregoing lines and need not be summarized in advance of their presentation in detail. Five observers furnished the experimental results here—the original three and two others.

The object of the check experiments was (1) to test capacity for performing similar tasks without hypnosis and the dissociation effected thereby; and (2) to determine whether, if equal capacity were revealed, the hypothesis of a co-consciousness is unnecessary to interpret the facts obtained.

The three chief observers were students taking the second or third year of instruction in psychology. The evidence of their normality is not in the form of a physician's certificate; it is that of my own observation of their adaptation to life. I have known them for three or four years, for most of that time in frequent personal contact with them as my students. I have seen them in the general life of a small college and in the social life of my home. In none of them have I seen any nervous stigmata.

J. L. B. has a good war record. In college he was a leading debater, a member of the 'varsity fencing team, played football, engaged in dramatics, and was a leader in his fraternity. He took

active part in social life. On graduation he went into business. His age at the time of experiment was 21–22.

G. E. H. was an editor of the college newspaper and was fond of social life. He had a keen and scholarly mind, being a member of the Phi Beta Kappa, receiving his degree with a *magna,* and being awarded one of our scholarships for graduate work. He is at the time of writing engaged in graduate study in Psychology and Philosophy at Harvard University. His age at the time of experiment was 19–20.

H. W. L. was an editor of the college annual. He took an active part in social interests, and engaged in dramatics. He is now a student of medicine at the Johns Hopkins University. His age at the time of experiment was 21.

Two other men, first year students in psychology, contributed a small amount of confirmatory evidence. P. J. was quarterback on the 'varsity and a member of the musical clubs. His age at the time of the experiments was 20. F. W. A. was an editor of the college literary magazine and a leading debater. His age at the time of the experiment was 20.

Let these details furnish such objective basis as they can for my judgment that these observers were normal.

These five men were obtained from some eight or ten, who requested that they might be tried out in preliminary tests. No one was urged nor even asked to take part; the opportunity was made known. Not much time was spent on any one of these volunteers, when dissociation was not pretty readily induced, except in the case of J. L. B. He was at first refractory but later proved to be an excellent observer.

In the conduct of nearly all the separate experiments three persons were employed at the same time—the experimenter (E), the observer (O), and the recorder (R). No more than one person at a time was in hypnosis. The records were made by R in longhand, with some modifications for speed and brevity.

The instructions given to O in Hypnotic Stage 1 were uttered distinctly and slowly, then repeated once in like manner; and at the close of this repetition O was asked, Do you understand? He would reply by a nod or a spoken word, usually the latter.

There was never an occasion to give the directions a third time, as O always professed to understand.

The arrangements for automatic writing occasionally involved placing a pencil in the concealed writing hand, but O sometimes picked up the pencil without aid. The writing was always badly formed, but improved somewhat as the experiments progressed. As in ordinary script, m's were sometimes incompletely formed. E had to keep watch to see that the paper was kept under the pencil and that later words were not superposed on earlier. Sometimes on reaching the margin, the hand would shift of its own accord. During the moving of the paper, the pencil sometimes remained on the paper and sometimes was lifted spontaneously. The use of a magnifying glass aided greatly in cases of doubtful interpretation, both as to characters written and the sequence of words, as the pencil was often not lifted from the paper in passing from word to word. A faint mark could many times be detected between words written in immediate sequence. E has tried very carefully to be objective in his interpretation of the recorded data.

The tests for anaesthesia of the concealed writing hand were conducted in the following way: O, having closed his eyes, was ready, whenever he felt himself touched anywhere, to report the fact at once with a "yes." E then applied finger or other blunt stimulus to hands, arms, thighs, and legs, mixing freely the tests of the writing hand and arm with those of other parts. In some experiments a sharp stimulus was used for the writing hand, to provide new material for discrimination and report on the part of the hypothetical co-consciousness. O was never told what sort of touch stimulus to expect on any part. After he was once prepared to expect the beginning of his test, he was given no further warning for any later stage of the same test. He was also kept in ignorance as to the correctness of his replies.

Each observer reported that he felt "normal," that is, he was in his usual condition of felt well-being, when he undertook a given experiment.

The method of hypnotizing employed was a combination of the so-called physical and psychical methods, viz., of eye fixation on a bright object, and verbal suggestion, followed, when the eyelids

closed heavily, by stroking and continued verbal suggestions. In the latter, emphasis was laid on creating a vivid imagination or " picture " of sleep in O's mind, or of bodily heaviness and muscular relaxation. E insisted also that O maintain deep and regular breathing. When hypnosis had been induced, the suggestion was always given that O would feel quite fit and ready for the remaining duties of the day when awaking; and that no one would be able to hypnotize him against his will. There was never any difficulty in terminating hypnosis and almost never any delay in accepting the suggestion to waken. O was usually asked after an experiment whether he felt all right. He almost invariably replied in the affirmative at once. The one or two exceptional instances and the nature of the mild discomfort are indicated in the reports of experiments. The only instances not there entered were of two persons who never yielded results of sufficient value to be included. One of these, being somewhat nervous, said, shortly after the first attempt to induce hypnosis, that he felt faint. Work was at once stopped with him and no further attempt ever made by E to resume it. The other person stated that his eyes had felt uncomfortable after a previous hypnosis, and requested that the eye-fixation factor of induction be omitted. E of course acceded at once to the request.

PART II

PROBATIVE EXPERIMENTS

EXPERIMENT 1.

Jan. 19, 1920, 3:30 P.M.

O: G. E. H. E: C. T. B.

HYPNOTIC STAGE 1:

O was told in hypnosis that E would give him a problem in the addition of three numbers, that he would awake on hearing the third number, and that he would give the answer at once on being rehypnotized. No amnesic suggestion was made. After a repetition of these directions, the numbers were given as follows: 27, 97, 82. O awakened at once as directed.

INTERIM STAGE:

Being set at automatic writing he produced the following. In this reproduction, and in all similar cases hereafter, the vertical lines indicate ends of lines in the original script, and the dots illegible parts.

Was to[1] (Here follows a rude five-pointed star and an irregular crescent-shaped figure) *add 3 nur 3 numbers | and nd give the | answer when rehy | hy*(p)*notised me they were | The probl |* (There is a large indecipherable conglomerate traced faintly around the two preceding words. A new sheet begins here.) *If you really wanted me to do it | I can do it but if you | don't I* (c)*ant. If you would | let me I would . . . why | . . . | why* (A new sheet begins here.) *97, 27, 82. You said to give you the | answer I can't t tell | you because I know you don't want* (These last two words are superposed.) *me too | want | I want to do it but I . . . | to and I can do . . . | if you | told me me | you want . . . If | But I can do it*

E meanwhile talked undisturbedly with O on various subjects irrelevant to the experiment. Questioned about his right hand, O was not aware that it was doing anything. Anaesthesia of that hand below the wrist developed spontaneously after some minutes of writing, as shown by tests with metal point and by pinching. When shown this hand, O could immediately feel touches upon it. It seemed colder than the left to E; and O rubbed it afterward, saying it felt clammy. Being questioned as to what occurred in Hypnotic Stage 1, O recalled everything except the specific character of the problem. Being asked why he could not, he replied that he did not want to, but that he knew from past experience that, if he should try, he would fail.

HYPNOTIC STAGE 2:

After a brief pause O said 206 (correct).

E: Why did you say that? O: Because you wanted me to give the sum of some numbers.

E: What numbers? O: 27, 50 (then, in succession, each after the third being meant to supersede the third) 98, 89, 92, 42 (resting on the latter).

[1] All matter in ( ) inserted into the automatic record by the experimenter.

E: How did you get the numbers? O: You gave them.
E: Why hesitate on the third? O: I couldn't remember what it was.
E: What were you doing while sitting at the table? O: Nothing. (Then, after a pause) Writing.
E: When did you do this sum? O: At the table.
E: What were you writing? O: Wasn't writing. (Then after a pause) Yes, I *was* writing—writing the numbers.
E: What else? O: Telling you why I couldn't tell you about the writing.
These answers came with apparent effort. "Why," asked E. "Don't want to say what I do," replied O.
E: How could you deny that you were aware of writing? O: Paid no attention.
E: When were you doing the problem? O: When we were talking.
E: How could you? O: Doesn't seem as if I could, but I was.
O's appearance showed marked alteration between forgetfulness and recall, with some confusion at times evident.

POST-HYPNOTIC STAGE:
O could recall nothing from Hypnotic Stage 2.

Probative character of this experiment: O performed a task, viz., writing intelligently, which, by the usual standards of life, involved mental functions. He was, meanwhile, not aware of so doing and was, indeed, engaged in carrying on conversation undisturbedly on topics disconnected with the task. Later, he recalled the details of this performance, though, meanwhile, he had had access to no source of information outside himself.

Associative relations among the several stages and subgroups: Hyp. 1 persists in part in the voice-group of Int.; and also in the hand-group, with no evidence of incompleteness. The two groups show no connection with each other. The voice-group loses kinaesthetic and touch sensations from the hand. Whether these persist with the hand-group does not appear, except possibly by inference. But visual sensations, belonging to the voice-group (sight of right hand) bring back the other inhibited sensations of that member. The voice group is affected by inhibitions from Hyp. 1. Hyp. 2 has not quite recovered from the dissociations and inhibitions of Int.; the associations are unstable; but it seems, however, largely to include that stage with Hyp. 1. The original numbers are still partly inhibited.

Post-hyp. seems wholly dissociated from Hyp. 1.

Other pertinent questions about these relations receive no answer in the records of this experiment.

EXPERIMENT 2.

Jan. 31, 1920, 4:30 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

HYPNOTIC STAGE 1:

Directions to O: You will be given a problem of three numbers. You will add the first two and substract from their sum the third number. You will awaken on hearing the third number. When you are rehypnotized, as soon as you think of the numbers you will lift your hand; and you will give the answer as soon as you are able.

After repetition of these directions in the usual fashion, the following numbers were given: 29, 56, 67. O wakened at once and took his place at the writing table.

INTERIM STAGE:

When questioned O said that he recalled nothing from the preceding stage. E began a discussion about dreams. Later he asked O to name the countries surrounding the Pacific Ocean. O replied correctly and in some detail, naming islands correctly, as well as divisions of Australia and capitals of some of them. He discussed primitive peoples and defined anthropology. This was all done without signs of effort. Meanwhile his hand wrote as follows: . . . *I have to add two numbers* | *which were 29, 57* (An 8 seems faintly superposed on the 7.) . . . *to take away 67* . . . *the* (?) . . . *was* | *answer was 18 I am to give the* | *answer* (?) *when. I am to give you the answer* | *when I giv* (?) *rehypnatised* (O's spelling) *and also* | *when I think of them I am to raise my hand* | *and give you* (end of sheet reached).

The back and fingers of the writing hand were anaesthetic to the sharp point of a compass. Questioned about his right hand, O replied, that it was on the table, doing nothing, just resting on the table. Being told to think about that hand he found it difficult to do so; the writing stopped and the anaesthesia disappeared. When told that he had been writing he could not recall the act, but said he guessed it had happened. He made clear that this was merely an inference on his part.

HYPNOTIC STAGE 2:

Being put to sleep O almost immediately[1] raised his hand and said "eighteen" (correct). Asked what he had been doing, he named the topics of conversation and said that this was all. Afterward he added that E had been touching his arm. (The record here is unfortunately ambiguous. Taken strictly, "arm" may mean either the right or left, as undoubtedly both were touched, in accordance with E's usual practice in such tests. This singling out of arm instead of leg, which was also included in the test, seems to point to some specially felt ground of distinction, such as an original anaesthesia might have conferred. Yet in this case "hand" should have been specified, as the anaesthesia did not exist above the wrist. The fault is evidently that of E in not drawing out further introspection from O on this point.) Asked "what else," he replied "nothing."

Here E observed that O's right hand was again making writing movements, the eyes being closed. The record obtained was the following: *which you told me to do I am* | *to do as you told me* | *to do when I was rehypnotized the first* | *time Badger* (the recorder) *is not to add these up* | *While I am*

[1] It is hard to choose the exact phrase here and in other similar cases, because it is difficult to tell the moment when hypnosis has been induced.

again (?) | *hypnotized . . . and the whole thing is to be done by m*(e) | (Here the writing runs off the paper as well as at the beginning of the next line.) . . . *isn't going to do* (?)

Being questioned O said he was doing nothing. E finding that the writing hand was anaesthetic to touch, asked O to think about that hand; whereupon the anaesthesia disappeared. Asked again what he was doing, he replied "writing"; and that he now knew that E had been touching him but that he did not know it at the time, "did not feel it then." O went on to say that the hand was writing the same as before. E: What was that? O: About the problem I had to do. Continuing, he said that he already knew the result, but did not know when he did it. (Both of these assertions are ambiguous and E can now only speculate on their meaning.) When writing he did not know that he was doing so, but does now; could not feel touches at the time, but remembers them now. "The rest of me couldn't feel it."

The suggestion was given that on awaking he would remember all about it.

POST-HYPNOTIC STAGE:

O feels as though he had been dreaming. Asked to make the attempt to recall, he says that he was told to recall, but can't remember what he was to recall. After some difficulty he remembers that he had recalled writing, not the act, but that he *said* he had been writing; also that he had told the subject matter, but could not now recall what it was. O remembers that E had touched his hand at those times when O, *at the time,* had said so; but at no others. He cannot recall where he was nor the presence of anyone except E. He has a slight feeling as though there were some things he can't recall. Now, he begins to forget still more, though he can still remember that he was told to recall, and what he has already said (*i.e.,* during Post-hyp.), but nothing else.

Probative character of these results: We find here in the Interim Stage the production of seemingly intelligent automatic writing, showing correct solution of a simple mathematical problem (one too complicated to be solved before O awoke from Hyp. 1, as shown by Check Exp. 1), while O was engaged also in complex conversation that required careful attention, and while professing to think that the hand, which was in fact writing, was merely resting. We find also within Hyp. 2, (1) the production of intelligent automatic writing, of which, at first, O professes ignorance, as well as of the stimulus applied to the writing hand; (2) the later recall of the content of the writing and the stimulus of the hand, though meanwhile no information has come to O from outside sources.

Associative relations among the several stages and subgroups: In Int. there is dissociation of hand-group from voice-group. This is not very stable. When the voice-group "attends to" the

writing hand (*i.e.,* develops voluntary images of the hidden hand) it recovers the lost sensations, but O finds it hard to do this. Hyp. 1 is dissociated from the voice-group but not from the hand-group.

Hyp. 2 is at first, according to all evidence that is free from ambiguity, a mere continuance of the inwardly dissociated Int. At first, associations with the voice-group appear alone; but the persistence of the hand-group appears thus: Hyp. 2 (or as we might perhaps now more clearly say), the voice-group of this Stage 2, denies further knowledge of the hand-group; but the automatic writing appears once more, reporting again correctly the matters recorded in the earlier writing. Then comes an increasing integration of the two groups. The touches on the right hand and the contents of the writing are shared. The recovered unification is expressed by O in a phrase referring to the previous dissociation: "The rest of me couldn't feel it." Part of the hand-group, viz., that concerned with problem solving, is not recovered.

The associative relations of Hyp. 2 to Hyp. 1 are shown in the completion of the task assigned in the latter, and in the continued reference to the task in the writing. The vocalized answer to the problem and the hand raising are not referred to during the remainder of Stage 2, an omission rather surprising in view of all that O does report on. Perhaps there was something about the act of vocalizing in response to the original suggestion that was—shall we say—distasteful, which determined its immediate dissociation from the remaining items of this stage. Pertinent facts will be adduced on this point from later experiments. Post-hyp. shows incomplete and unstable associations with Hyp. 2 and none with earlier stages. The suggestion had been given in the preceding stage that all would be recalled in this. At first, Hyp. 2 is recalled vaguely (O feels that he has been dreaming). Then (after O has been urged to effort) lost items from the preceding stage are recalled (viz., that he had been told to recall something). Then, with further effort, O recalls telling what he had written, but cannot recall what its content was. He has a vague feeling of yet more unrecalled. Even as he talks he begins to forget again.

EXPERIMENT 3.

April 13, 1920, 2:30 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

(This was the second experiment upon this observer at this session.)

HYPNOTIC STAGE 1:

Directions to O: You will multiply two numbers. The first is 85. The second is the number of shelves in the book-case to the right of the door. (This number was 6. O's eyes were, of course, closed at this time, but the book-case was near by and in full view from his chair.) When you get the second number you will at once fall into hypnosis, giving the answer as soon as possible, and raising your hand the moment you begin to think of the problem. (These directions were repeated; then) "Do you understand? (Affirmative reply.) A copy of Aesop's Fables, opened, was then put into his hands. He was told that, on awakening, he would begin at once to read the left-hand page. He was given an amnesic suggestion for the events of Hyp. 1.

INTERIM STAGE:

Awakened, he began to read at once, well and intelligently. Stopping at the end of a page, he was told to finish the fable.

E: Why did you stop at the bottom of the page? O: I don't know why. I did so naturally. It must have been a post-hypnotic suggestion. (This behavior was probably in strict accord with the form of the suggestion, although not so intended by E.)

E: What can you recall from your previous hypnosis? O: Nothing.

E: Try. O: Nothing.

O was then tested for suggestibility. Being told that he could not lift head, put hand down, open mouth, etc., he did them all. Being told that he could not help saying 80 (chosen because of its connection with the original suggestion) on seeing O take out a watch, he did not say it; yet he resisted with some apparent effort; and he afterward acknowledged that he wanted to say it.

E: Do you recall anything? O: No.

E: Do you feel perfectly normal? O: Yes.

E had observed that early in Int. O had turned his shoulder toward the book-shelves, in such a way as to exclude them from his immediate field of view. So wondering why O was not executing the original suggestion, E continued to test O's suggestibility in several ways, till resistance seemed to require some effort, though it was always successfully made. When told he could not move a certain member he would sometimes reply that he did not want to.

O was now told to turn his head; he did so to the left (away from the shelves). Noting the obvious reluctance to turn toward the right, E told him to turn the head all around. Pausing a moment, O then gave it a big twist away round to the left. He was now told directly to move his head to the right. He did so with ample motion and speed so great that he need not have seen the shelves at all—much more rapidly than in turning the other way. Finally, "Move your head *slowly* to the right." He obeyed: and

HYPNOTIC STAGE 2:

instantly dropping back into the chair with closed eyes, he raised his hand

and said 510 (correct). Tests for suggestibility now showed that O was in hypnosis.

E: Why did you lift your hand a few moments ago? O: When was that?

E: A little while ago. O: Oh yes, I thought of a problem.

E: What were you doing? O: Doing problem while my hand was raised.

E: Before that? O: Looking at book-shelves.

E: Before that? O: Moving hands (referring evidently to the tests for suggestibility in Int.).

E: Why did you move your head to the right so hurriedly at first? O: I was afraid to see the book-case.

E: Why? O: I didn't know that was why.

E: (Persists in asking why.) O: On seeing book-case I would go to sleep; and I didn't want to then because I was talking with you. But I didn't know that was why.

POST-HYPNOTIC STAGE:

O states that he remembers no events of Hyp. 2 nor the fact of falling asleep (*i.e.*, in Stage 2). He resists suggestions easily. Being pressed for further recollections, he offers a few vague memories of Int. that feel to him indistinct and confused. He remembers talking, as in a dream, and is not very sure of even that. He feels as though he had before been going through the limb movements he had just been making (*i.e.*, resisting by movement the suggestions of motor paralysis). But all these things seem less real than, for example, his going to R's room at the beginning of the afternoon. Moving arms, legs and head is all he can recall.

E: How? O: Slowly.

E: Remember anything else? O: That is all.

E: What way did you move your head? O: Both ways.

E: Did you have control? O: I think I did.

E: Do you recall anything else you have done this afternoon? O: Yes, reading fables. (This was done in the Interim Stage of an earlier experiment on this same afternoon and was recalled in the Post-hypnotic Stage of that experiment. It is thus not necessary to interpret the present memory as a reference to the present experiment.)

To check up the point as to whether O had known the number of shelves in advance of the experiment, E asked him two days later how many shelves there were. He replied that he did not know. He stated also that he had no memory of having had anything to do with them in hypnosis, though he remembered being told that they had sent him off into that state. He did not recall ever having noticed their number before the experiment.

Probative character of this experiment: The evidence for co-consciousness consists in the following: O professes in Int. to recall nothing from Hyp. 1. His actions, however, are apparently affected by *resistance* to the suggestion given in the latter stage. In Hyp. 2 he has become aware of the resistance present in Int., though he has had no outside information. Telling of it, he adds he was not at the time of this occurrence aware of the

meaning of his acts, viz., that they were of the nature of resistance.

Associative relations among the several stages and subgroups: Hyp. 1 is entirely dissociated from the voice-group of Int., but not from the resistance-group, while the latter is dissociated wholly from the voice-group. Int. as a whole is in full associative relation with Hyp. 2, and so is Hyp. 1, as far as the carrying out of the original suggestion is concerned. From Post-hyp. are dissociated both of the preceding hypnotic stages, and there is only fragmentary association with Int.

EXPERIMENT 4.

April 30, 1920, 3:30 P.M.

O: H. W. L. E: C. T. B. R: G. E. H.

(This experiment immediately followed another upon the same observer.)

HYPNOTIC STAGE 1:

Directions to O: You will add two numbers. The first is 639. When I give you the second you will waken at once and write the answer automatically. You will not remember what I have now said. (Directions repeated; then) Do you understand? (Affirmative reply.) The second number is 427. (O wakens at once.)

INTERIM STAGE:

E: What do you remember? O: About my writing—a lot about the writing (referring evidently to experiences in the preceding experiment on the same afternoon)—that's all.

O seats himself at the table, right hand behind screen. It writes at once upon taking up the pencil 1066 (correct), and repeats the number very many times. The second time it appears as 10 followed by a 6 reversed (mirror writing), and then two 6's correctly made. This extensive repetition was not a part of the original suggestion so far as E is aware or the records indicate. O states that his right hand feels colder and more numb than the other.

E: What are you doing? O: Moving the hand, as I usually do when I hold a pencil.

Tests of anaesthesia were negative. The account as given above shows that exploration for awareness of the real meaning of the hand movements was not as extensive as it properly should have been; but it seems not improper to assume, that had O known what he was really doing he would have said so in reply to the last question.

HYPNOTIC STAGE 2:

E: What were you doing when sitting at the table? O: Writing.

E: What? O: 1066 (correct).

E: What is that? O: The answer to the problem you gave me (correct).

E: When did you perform the problem? O: Don't know.

E: (After a pause) Can you think now when you performed it? O: No.

E: Did you perform it before you sat down in the writing chair? O: Don't know.

E: Did you perform it before you awoke? O: I woke up when you gave me the second number.

E: Why didn't you tell me what your hand was writing? O: Didn't know it was writing.

E: How do you know now? O: Don't know. (Presumably, in view of other statements by O, this was not intended as a denial that he knew that he had been writing, but rather as a denial that he knows how he knows.)

E: Do you know you wrote it? O: Think I did.

E: Do you recall actually writing it (*i.e.*, the act in process)? O: No.

Yet he had already stated, without access to information outside himself, that he had been writing. This seems to indicate fluctuating associative connection between the hand-group of Int. and Hyp. 2.

E: Are you asleep or awake now? O: Awake.

E: If awake, why can't you take your arms off the chair? (O cannot lift his arms from the chair.) Can you when awake? O: Yes.

E: You are going to begin to laugh now. (O does so.) You are laughing on one side of your face and weeping on the other. (Not well carried out, the weeping effect predominating, but without tears here and below.)

E: Now are you asleep or awake? O: Don't know.

E: How does your present state feel? O: I'm very comfortable.

E: Why don't you know whether you are asleep or awake? O: I thought I was awake.

E: You will be sad and weep. (O accepts the suggestion.)

E: Are you comfortable now? O: No.

E: What are you weeping about? O: I don't know.

E: Do you feel comfortable? O: I don't know. (See reference to this in Post-hyp.)

E: You are not weeping; you're laughing. (O does so.)

E: Will you tell us the joke? O: I don't know what it is; I just feel good.

E: You are putting this on. O: I'm not.

E: This is acting, isn't it? O: No.

E: You are laughing because your left hand is a humpty-dumpty. O: (Laughing more than ever) It feels like an egg.

He is next told that he can open his eyes, but remain asleep. He is then given the suggestion to see a motto over the door. It is not accepted. Being told that his hand looks like chalk, he agrees.

POST-HYPNOTIC STAGE:

E: What do you remember? O: Weeping. laughing.

E: What were you laughing at? O: Nothing, as I remember.

E: Did you feel very much amused? O: Yes—more so than I usually do when I laugh.

Being told to look at the chair-arm, he recalls the humpty-dumpty. He also reports that he felt terribly when weeping.

E: Wasn't that crying acting? O: No. It seemed as if something terrible had happened; and I felt all broken up over it.

He reports, further, that being asked, while weeping, whether he was comfortable, this word did not seem to have any meaning for him. This perhaps indicates the depth of his absorption in the suggestion. The foregoing account indicates that E did not explore fully for memories of Int.

Probative character of this experiment: We have here the execution of a mathematical task according to a plan while the individual is apparently unaware of so doing. Yet later, without information meanwhile from any source outside himself, he reports what he has done.

Associative relations among the several stages and subgroups: Hyp. 1 is associated with the hand-group of Int., but not with the voice-group. It is also associated with Hyp. 2. There is no evidence as to whether it survives in Post-hyp. In Int. the hand-group is partly dissociated from the voice-group, *i.e.,* so far as the *meaning* of the right hand movements is concerned. About the reverse relation between these groups there is no evidence. Both are associated with Hyp. 2, when they are reunited. The latter is associated, in turn, with Post-hyp.

Comments: (1) The chief experimental defect in the foregoing is, perhaps, the failure to explore still further O's apparent unawareness in Int. of the meaning of his right hand movements. (2) The ease with which the problem was solved is worth noting. The testimony of O implies that it took place during Int., and by the promptness with which he wrote the answer on picking up the pencil, the latest limit is set. During that period he was making the usual effective social adjustment to E in the matter of question and answer. As to his ability to make such a complicated adjustment, without the aid of hypnosis, the series of experiments affords no answer—a regrettable omission. (3) The kind of resemblance between hypnosis and the normal state is not introspectively clear to O, as shown by his change from certainty to doubt, while E plied him with suggestions. At first he declares himself "awake"; at the last he doesn't know. (4) Emotions of some apparent strength can be aroused in hypnosis, with little or no ideational content (representing no definite object toward which the emotion is directed).

EXPERIMENT 5.

May 4, 1920, 4 P.M.

O: G. E. H. E: C. T. B. R: H. H.

HYPNOTIC STAGE 1:

Directions to O: I am going to give you two numbers. The first is 93. The second I will give you on a piece of paper when you waken. If it

appears in ink of one color, add it to the first number; if in ink of two colors, subtract it from the first. (Directions repeated carefully; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

E: Can you tell me what has happened? O: I don't know; I can't remember.

E: What is the best you can make of this I-don't-remember? O: I can't make anything of it. I can't remember because I have nothing to connect it with.

E: Are you willing to make an effort? O: I haven't anything to put any effort on.

E: Is it like trying to report what is on the fourth street on the right, up from the harbor of Canton (taken as an example of matters utterly unknown to O)? O: Yes, I have nothing to put any effort on.

O now takes his place at the table. The writing hand is not anaesthetic.

E: Do you feel sleepy? O: No.

E: Do you feel as if there was something on your mind? O: No, I feel rather dreamy; I can't think of many things.

To O is now shown a card with 57 on it in red and black.

E: What does it recall? O: A card I saw once before with red and black numbers on it.

E: Nothing else? O: No.

E: Are you telling me the truth? O: Yes.

E: Does it bother you to have me ask that? O: No.

O's writing is now in progress. Tests show that the writing hand is anaesthetic. Being given a book. O reads rapidly aloud, while his hand makes the figures 36 (correct) over and over again, filling a sheet.

E: What are you doing with your right hand? O: Nothing.

O gives an account of the content of his reading.

Tests for suggestibility show that the head and left hand are completely resistant, but that the right hand yields, showing paralysis, movement, and inability to stop movement, according to the word of E. O is aware of all this. ("That is because my right hand feels differently than it usually does.") E: The sight of that hand will put you to sleep. O falls asleep at once and is helped back to the easy chair.

HYPNOTIC STAGE 2:

O tells what he has been talking about, what he wrote, and says that the latter was the answer to the problem given him.

Here a fellow-worker of O in the laboratory, well known to him, comes to the door to speak to E. Being questioned about this, O replies that he knew some one came, but not who it was. The door was very near O, but his eyes were closed. He is well oriented in time, guessing the hour within fifteen minutes too early. O is given the suggestion to recall all when he awakes.

E: Did you know I touched your (right) hand? O: I know now you did.

E: How? O: Because I remember it.

E: How can you remember now and not have known it then? O: I wasn't thinking of it then.

E: Were you feeling normal then? O: No, not quite normal. I kept thinking of one thing, that is, whatever I was looking at.

E: Are you asleep or awake now? O: I'll call it asleep.

E: What is it? O: It is really being asleep.

E: Now when you wake up I want you to remember what has taken place. Do you think you can do it? Is it an effort to do it? O: Yes.

E: I want you to tell me what the effort consists in, when you wake up. You will awaken when I rap three times.

POST-HYPNOTIC STAGE:

E: Can you remember? O: I suppose so, but I don't really want to; it's such a hard thing to do. I don't want to say what it was. It's hard to say. I remember sitting at the table then and writing the number 36 and being touched on the hand.

E: What else do you remember? O: Telling you I didn't feel quite normal when I sat in the chair.

E: Now you are going to tell me in what the effort consists. O: First in trying to remember and then in trying to say it.

E: Is it comparable to anything else? O: Like some unpleasant thing you try to forget.

E: The writing? O: No, the remembering.

E: The content, or the trying to remember? O: I guess it must be trying to remember, not the content.

E: Is it like learning a lot of Latin verses if you hated to learn the Latin and hated to hear it spoken? O: Yes.

E: Have you ever felt that way before? O: Yes. After I say it, it seems to be off my mind, but I wouldn't want to say it again.

E: Emotionally, how does it seem to you? O: I dislike to think about it.

E: Do you know why? O: No.

E: Have you felt similarly in similar experiences? O: Yes.

E: Do you now feel different from the way you felt in this chair (the one at the table)? O: Now I can think of everything; then I felt sort of dreamy.

E: How did you feel about your right hand (*i.e.*, when it seemed independent of O's control)? O: I didn't feel as if it were mine.

E: Was it hard to think of the whole experience? O: Yes, both the chair experience and the writing.

E: How do you feel now? O: Relieved from the ordeal. I feel better when I forget it all. It seems disagreeable when I am awake and remember it because it is so inconsistent.

Probative character of this experiment: O performs a problem in subtraction after deciding whether, according to the color code agreed upon, the figures call for subtraction or addition, and he writes the answer, professing, at the same time, to be unaware of it all and of what he had been originally told to do. While recording the answer over and over, he is reading a text with such understanding as to be able to report on it afterward. In a later stage he recalls both groups of facts, without, meanwhile, having received any outside information.

Associative relations among the several stages and subgroups: Hyp. 1 is dissociated from the voice-group of Int., but not from

the hand-group, nor from Hyp. 2. In Int. the hand-group is dissociated from the voice-group (except for a certain area of experience which is apparently shared, *i.e.,* the visual); but we find no evidence that enables us to assert to what extent, if at all, the voice-group is dissociated from the hand-group. Both of these are associated with Hyp. 2 and Post-hyp. Hyp. 2 also is associated with Post-hyp.

Comments: The following subsidiary facts, indicated in this experiment, are worth bringing together for easy availability: (1) Int. was not normal. O felt dreamy, monoideic. (2) The right hand was not anaesthetic when tested prior to the writing. (3) O explains this anaesthesia by saying, "I wasn't thinking of it (the touch) then." "I know now you did." (4) He is not quite sure whether to call the hypnotic state one of sleep, but finally accepts that characterization. (5) How shall the felt difficulties in recalling the events of Int. be regarded? O informs us that effort is involved in two things—trying to remember and trying to say it, as if it were something unpleasant that one would gladly forget. He has felt the same way in other similar experiments. The form of his report seems to indicate on the one hand honesty in his introspection during Int., and on the other the discomfort of confusion in logical processes. There is no evidence of concern lest anyone should think him lying. (6) While in hypnosis, and not occupied with the execution of detailed suggestions, O obtained new sensory material and was oriented in time. (7) The dissociation in Int. is clearly pointed out in post-hypnotic recall by O's statement that the writing hand, anaesthetic while executing special suggestions, did not feel as if it were his.

EXPERIMENT 6.

May 20, 1920, 3:30 P.M.

O: H. W. L. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: I am going to give you a problem. You are to multiply two numbers. The first is the number in the right-hand corner of the book page which you are looking at when I ask you to hand me a book. The second is the number of taps you hear me make while you are looking at the book. The answer you will write automatically without knowing you are doing so. (Directions repeated as usual; then) Do you understand?

(Affirmative reply.) O then woke according to the suggestion that he would do so when asked to sit in another chair.

INTERIM STAGE:

E: Do you remember what has been happening? O: I can't remember anything.

E: What is it like? O: A blank.

E: Are you asleep or awake? O: Awake, I guess.

Tests for suggestibility are negative. Being handed an open book of Aesop's Fables, he is asked to look for a page containing three fables. While O is searching, E makes three taps and takes the book away (at p. 41). By request O then repeats some verses that he knows by heart ("Bowdoin Beata") and does so easily, without obvious distraction. At the same time his right hand is writing over and over again 123 (correct), usually in a column, but occasionally in a row. (Five times, scattered through a series of thirty-seven, 133 appears instead.) Tests for anaesthesia of writing hand are now positive.

E: What are you doing? O: Nothing.

E: What do you hear? O: A pencil. (O's pencil was making a very perceptible noise.)

E: Whose? O: May be George's (R) pen.

E: Are you awake or asleep? O: Awake. (O acts very sleepy, but refuses motor suggestions.)

E: What is your right hand doing? O: Nothing.

He is then told that he cannot hold his eyes open, and he thereupon falls asleep. He returns to the easy chair.

HYPNOTIC STAGE 2:

E: What have you been doing? O: Nothing.

E: Why didn't you tell me when you were writing? O: I didn't know I was writing.

E: Did you hear noise of a pencil? O: Yes.

E: Why did you say it was George's pencil? O: Because he was writing.

E: Did you feel my touches on your hand? O: No.

E: On your arm? O: Yes.

E: Did you really not feel them at all on your hand? O: All I felt were on my arm.

E: Do you recall now feeling them on your hand? O: Can't seem to think.

E: Were you awake or asleep while writing? O: Awake.

E: How did you feel when I told you you couldn't do certain things? O: Felt sleepy.

E: Like falling into hypnosis? O: Yes.

E: What were you writing? O: 123.

E: What was that? O: Answer to problem.

E: What was the problem? O: Multiply number on the upper right-hand corner of page you handed me by number of taps.

E: Do you remember any of the fables on that page? O: One about a wolf (correct).

E: Were you aware, at the time, of looking for the number of the taps? O: No.

E: When did you do the problem? O: Right after you took the book.

E: Were you aware of doing the problem? O: No.

E: Were you thinking of anything else while repeating Bowdoin Beata? O: No. I felt sleepy all the time.

E: More so than usual? O: Yes.

E: More than you do now? O: Yes.

E: Can you wake up now if you want to? O: I think so.

E: Do you have any such difficulty in speaking as George had (referring to peculiar features of an earlier experiment reported in this monograph as Exp. P.)? O: No.

E: Yes you do. O: No, I don't.

E: Yes you do.

Here O works his face as if trying to speak, but utters nothing.

E: You can't say your name. (O makes an unsuccessful effort.)

E: Can you recall what it is? (O nods.)

E: But you can't say it? (O shakes his head. His right hand moves as though writing. Thereupon he is made to sit once more at the table with his hand behind the screen. His replies, recorded in the following dialogue, were given in writing.)

E: Why can't you say it? O: You told me I had the same trouble as George.

E: Can you think how to say it? O: Yes.

E: How? (O writes his name.)

E: Can't you utter it? O: No.

E: Have you seen anyone with this difficulty before? O: Yes.

E: Who? O: G..... H..... (correct).

E: Now your difficulty is removed. (O speaks his name, and writing stops.)

E: Can you answer questions now? O: Yes.

E: Why couldn't you before? O: Couldn't speak.

E: Did you try to? O: Yes.

E: What prevented it? O: Don't know.

E: Do you want to wake up? O: Don't care.

E: Are you comfortable? O: Yes.

E: What are you thinking about? O: Nothing.

E: How did you get the solution of your problem? O: I heard three taps; and as soon as I got the number from the top of the book I multiplied them.

E: As you do ordinarily? O: Yes.

E: You will start to take your fountain pen from your pocket, and when you do, it will waken you. Do you hear any noise now? O: (After a long pause, though the sound is easily recognized by the ordinary ear, and O is himself musical.) It sounds like music.

E: Like what instrument? O: (Listening hard.) It sounds like an organ (correct).

O then starts to take out his fountain pen, though he had only a pencil in his pocket; and wakens.

Post-hypnotic Stage:

E: What woke you? O: Your telling me to take a fountain pen out of my pocket. That didn't seem right since I knew I didn't have one; but the more you suggested it, the more I thought I did have one.

E: What else do you recall? O: Problem.

E: Can you remember it? O: I think I can. (He states it correctly.)

E: Do you remember doing the problem? O: No.

E: Do you recall anything else about your sitting at the table? O: Feeling very sleepy, reciting Bowdoin Beata, nothing else.

E: Do you remember any automatic writing? O: I think I can—not sure. I remember your asking me about it, but I don't remember doing it.

E: Do you remember anything else? O: I never felt before as I did when I sat at the table (in the Interim Stage). I felt numb, and finally awoke; but I could do the things you said I couldn't. There is something else I'd like to say but can't. Don't know what it is, but I feel there is something there.

E: Do you feel now the way you did when looking at the book? O: No. (Here tests for suggestibility were negative. O went on to say that he did not feel comfortable when sitting at the table; he wanted to go back to the easy chair.)

E: Do you recall any difficulty of speech? O: I think that's what I wanted to tell you about. As soon as I took a breath to say something, it seemed to stop.

E: Did it bother you? O: Yes, because when I tried to talk my breath stopped. It was like trying to talk after you've run till you're out of breath.

E: Did you try to do anything? O: Yes, writing automatically. I didn't like not being able to answer so many questions; and writing relieved my mind—to be able to say anything.

E: Do you remember anything else? O: A band. (Record does not show whether this is correct. It is not improbable.)

E: Do you recall an organ? O: No.

Probative character of this experiment: O gathers information and performs a task according to a plan. Of all this he appears to be unaware; and a part of it at least (the writing) is being done while he seems to be fully occupied with another task that requires attention for its execution and receives enough to make its content remembered. O is able later to recall leading features of both tasks without resort to any source of information outside himself.

Associative relations among the several stages and subgroups: Hyp. 1 is dissociated from the voice-group of Int., but not from Hyp. 2. No direct associations with Post-hyp. are apparent. In Int. the hand-group is dissociated from the voice-group, but reunited in Hyp. 2. The hand-group, however, is dissociated at least in part, perhaps wholly, from Post-hyp., but not so the voice-group. Hyp. 2, in turn, is in association with Post-hyp.

Comments: (1) The scope of Hyp. 2 is narrower than with G. E. H. The touches on the anaesthetic hand of Int. are not recalled, though the writing is not forgotten. (2) The suggested dissociation of the speech function does not involve ideas of that

function (as in the spontaneous case of G. E. H. See Exp. P). (3) There seems to be some resistance to the recall of the speech failure episode. (4) The recall, in Post-hyp., contrary to the rule, is largely spontaneous; that of Int. was due to, or furthered by, a suggestion in the preceding stage. (5) The abnormality of Int. is shown by sleepiness and yielding to suggestion. (6) Anaesthesia of the writing hand to touch is, as usual, spontaneous.

EXPERIMENT 7.

May 27, 1920, 2:30 P.M.

O: G. E. H. E: C. T. B. R: H. W. L.

HYPNOTIC STAGE 1:

Directions to O: When you awaken I shall have you sit at the automatic-writing table. I shall show you a number. If it is in ink of one color, you will record for me what happened during the dinner hour; if in two colors, you will record the events of the hour just preceding this present one. You will be unaware of this (*i.e.*, what E has said) after you waken and while you are writing. (Directions repeated; then) Do you understand? (Affirmative response.)

INTERIM STAGE:

O takes his seat at the table.

E: Can you remember anything? O: No.

E: What does it seem like? O: Like so much time lost. Seems a little as though I had been asleep—not much different. I do not feel as I do when I awaken in the morning.

E: Do you feel awake? O: Not as alert as usual.

His right hand is not anaesthetic.

He is now shown a paper on which 29 appears in ink of one color. His concealed right hand immediately begins to write while he asks: "What is it?" (See his statement in Hyp. 2 that he did not know what it meant.)

E: What went on last hour? O: I was in the music room taking tests (correct).

E: Did you find them difficult? O: Yes—the rhythm one in particular.

E: What happened this noon? O: Everything—Junior marching.

E: What can you tell me about it? O: We marched in Memorial Hall. There was not good attendance.

E: What happened at the house? O: A meeting directly after dinner.

E: Do these questions remind you of anything? O: No.

The following writing has been produced meanwhile.

At about 12:30 I went into the | dining room and sat down to the | table— [1] *H..... at my left | . . . L..... at my . . . | S..... directly across the | table we had meat and | . . . potato and biscuits . . . and | then all the Juniors went over | to Mem Hall after we ha* (ran off paper) *| a meeting around the | fireplace D..... want* (ran off paper) *| know about the Steward'ss account | going innto the Hop Com-*

[1] All proper names were written in full.

mittee | . . . And after the marching | we went over to the House | and then to the Psych lab from | the house with L..... W.....
(This writing is apparently in accord with the directions given O; the accuracy of details cannot be checked up.)

Tests for anaesthesia of the right hand, at the close of the writing, are positive. Movements to be executed by the hand are not accomplished, though O thinks he has done them; but he has his left hand under full control. With the removal of the pencil from the right hand, feeling gradually returns, and full control.

E: Do you feel awake now? O: More than I did.

E: Do you connect with anything this beginning of more wakefulness? O: No; but I think your asking me so many questions woke me up.

E: Do you recall anything from hypnosis? O: No.

Tests of suggestibility are negative. Being shown the paper on which was the writing he had just produced, he does not recall having written it; nor does it call anything to mind. (The record does not state whether O was allowed to read the contents; but it is probable that he had a mere cursory glance. For further confirmation that O was unaware of writing, see the next experiment of the same afternoon—Exp. 8—and his reference, during the Interim Stage, to the present experiment.)

Hypnotic Stage 2:

E: What were you doing at the table? O: Writing what happened this noon (apparently correct).

E: What did I ask you? O: What I did at noon (correct).

E: (Apparently in the hope of getting details.) What were you writing? O: What I did this noon.

E: Did two things seem to be going on together? O: Yes, I knew what I was writing for a few minutes.

E: What do you mean? That while talking you knew about your writing? O: Yes.

E: When precisely were you aware of it? O: When you asked me what I was doing. I forgot it immediately after I finished answering. (If O's words be taken verbatim, the record does not show that this question was either asked or answered. As O is probably correct in this remembrance, such an omission would be serious, since we are unable to compare his original answer with his present recollection. If, on the other hand, O's words be given a loose reference, they may refer to the question, "What happened this noon?" In that case O's answer to the present question and a few immediately following mean that when E questioned him about events that were also the theme of his writing, he became briefly aware that he was indeed writing about them, but directly afterward lost that awareness.)

E: Do you refer to my first question? O: To that and one or two others.

E: When I asked the question, you thought both of what you were writing and what you were saying? O: Yes, when you asked me the question about this noon.

E: Did my questions seem to influence your writing? O: I don't know.

(This revelation that the hand-group was united for brief intervals with the voice-group—a combination effected, apparently, by the special conditions of this experiment—leaves still a tract of the Interim Stage about which to draw conclusions for the main purpose of this experiment.)

E: When did you begin to feel less sleepy? O: After I finished writing.

E: Do you remember that I asked you that question while you were at the table? O: Yes.
E: What answer did you make then? O: That I felt less sleepy when you asked me so many questions.
E: Was that a correct answer? O: Not exactly—it seemed correct at the time; for I didn't know exactly.
E: Did the number mean anything to you? O: No.
E: What do you think of between questions? O: Nothing.
(Post-hyp. is lacking because a new experiment was begun at once.)

Probative character of this experiment: O selects a task to be done according to a previously arranged code and executes it, while, in some sense, unaware of what he is to do and, at least for a part of the execution, unaware that he is doing it. Later he recalls what he has done, though meanwhile without information from any source outside himself; and recalls the fact of dissociation (see Exp. 8).

Associative relations among the several stages and subgroups: With the aid of suggestion, Hyp. 1 is dissociated from the voice-group of Int., but not from the hand-group. There is no evidence as to its connection with Hyp. 2. In Int. the hand-group is part of the time dissociated from the voice-group and occasionally reunited with it, on the stimulus of questions that concern common areas of fact. Both are united again in Hyp. 2. A suggestion in Hyp. 1 is a factor in the stage succeeding Hyp. 2, as shown in the second experiment of this date (Exp. 8).

Comments: (1) While executing a suggestion unconsciously, O feels sleepy. This feeling passes off, says O in Hyp. 2, when the suggested function is ended; but in Int. he attributes the renewed alertness to E's continued questioning. (2) An important new feature of this experiment is the attempt to discover the effect upon the associative relations of the two groups in Int. of questions directed to facts known in common to both groups. That effect is to bring about temporary association, but is very fleeting. (3) The hand-group has a better access to the noon-hour events than the voice-group, if fullness of report be the test. (4) The force of the inhibitions that keep the groups apart is indicated by the fact that when the voice-group has access to a sight of the written paper, no pertinent memories arise. (5) Again we note the lack of thinking, in the hypnotized mind, when

left to itself. (6) The delusion of control over the right hand, when that system is dissociated, raises the question as to the felt signs of voluntary action. (7) The removal of the pencil from the writing hand seemed to be sufficient to remove the inhibiting impulse that conditioned the dissociation. In what group of psychic items was its locus? Does the hand-group "fend off" the voice-group? The latter seems in all these experiments to play a relatively passive rôle.

EXPERIMENT 8.

May 27, 1920, 3:30 P.M.

O: G. E. H. E: C. T. B. R: H. W. L.

(This experiment immediately followed another on the same observer.)

HYPNOTIC STAGE 1:

(Named so for convenience. It is identical with Hypnotic Stage 2 of Experiment 7.) Directions to O: When you waken I shall give you a book to read. If the number of lines in the fable is more than 10 you will say Boston automatically; if less than 10 you will say New York automatically, without knowing you have said it. (Directions repeated; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

O recalls nothing that has just been going on. He resists suggestions directed to motor control, saying he would rather not lift his arm. He feels sleepy. Being handed the book he reads the fable aloud; and, finishing, he immediately says "New York," a correct fulfilment of the suggestion.

E: What is the last word you said? O: Pieces (the last word of the fable).

E: What have you just read? (O tells the story correctly.)

E: Were you doing anything else while reading? O: No. (Later in this stage, he contradicts this statement by his written word.)

E: Are you sleepy? O: No.

E: Are you more waked up than a while ago? O: Yes. I woke up gradually by reading, I guess.

E: Do you remember now what you did at the table? O: Yes—talking with you and writing about what I did this noon. I did not know I was writing. (Experiment 7 is here referred to; and this bit of evidence is referred to in the discussion of the probative value of the earlier experiment.)

E: What did you say when you finished reading the fable? O: I said "pieces."

E: Why? O: You asked me what the last word I said was.

E: Was that the last word? O: Yes.

O is now directed to sit at the table and, with pencil in his screened right hand, is given the opportunity to write, but without verbal suggestion to do so. The hand at once accepts the opportunity.

E: What was the word you uttered after the fables? O: (Speaks.) Pieces; (writes) *New York.*

E: What were you thinking about while reading? O: (Speaks.) Nothing except about reading the fable; (writes) *Counting the lines.*

E: Did you feel that you were giving attention to the case (*i.e.*, the reading)? O: (Speaks.) Yes. (Writes an illegible scrawl.)

Tests of right-hand anaesthesia are now positive. During these tests the hand is writing the number series from 1 to 14, trailing after that into illegibility what may be intended for higher numbers in the series, and ending with a word-like scrawl. E gave no intentional suggestion for this writing. It may have been the expression of line counting or of the counting of touches impressed on his anaesthetic hand, or, indeed, have some other meaning. O is now plied with suggestions for sleep, which he does not accept.

E: But you want to, don't you? O: Yes.

E: But you don't intend to? O: Not unless you want me to.

(It is an error of technique that E did not question O as to whether he knew that he was writing and what the contents were. The answers, coupled with the proper inquiries and answers of Hypnotic Stage 2, might have made this important evidence.)

Hypnotic Stage 2:

(Again, named so for convenience; this is really the third hypnosis in sequence.)

E: What was the last word you said after reading the paragraph?

O is silent, even when the question is repeated several times. He is then sent to the table and given a chance to write under the usual conditions, but without verbal suggestion to do so. The record has no entry as to the stimulus used to make O go to the table. It would seem that he must have been led; but one queries, of course, whether here, with apparent inconsistency, he responded to an auditory stimulus. The answers to the following questions, to the end of this stage, were all obtained in writing.

E: Do you hear me? O: *Yes.*

E: Why don't you reply to me? O: *I can't.*

E: Why not? O: *Because I can't speak.*

E: Do you want to speak? O: *I don't know. I can't hear what you say to do* (This word—if this be the one intended—runs partly off the paper) | *things.*

E: What do you mean? O: *I can't hear what you say* | *to do anything I can't hear you.*

By direction of E, R calls O by name.

E: Do you hear Henry speak? O: *Yes, but I don't.*

E: Don't what? O: *Hear him.*

E: Do you feel my touch on your hand? (Unfortunately the record does not show which one was touched; of course, E believes it to have been the writing hand.) O: *Yes, but I don't.*

E: Don't what? O: *Feel it.*

E: How can you feel it and not feel it at the same time? O: *I don't think I feel it but I do.*

E: Will you try to remember about this when you are wakened? O: *Yes.*

E: Do you think it will be hard to remember? O: *Yes. I don't think I can.*

E: Why? O: *I don't know.*

E: Let me see you lift your left hand. O: *I can't hear you.*

E: Do you feel comfortable? O: *Yes.*

E: Would you like to be waked up? O: *Don't care.*

E: Are you any more deeply asleep than usual in hypnosis? O: *In a different way.*

E: How different? O: *Don't know.*

After being given a suggestion that he will be able to recall the experience, O is wakened. This takes place without difficulty, and, presumably by the usual auditory cue.

(With regard to the main purpose of this experiment, it is an error in technique that, in Hypnotic Stage 2, O was not questioned about the line counting, to discover whether he could recall it and whether he felt that, at the time of counting, he was unaware of it. E's surprise at the turn taken by the experiment is the explanation for this omission. This seems to be supplied fortunately by the written statement on this point, obtained in the Interim Stage. But for the failure to inquire about this writing itself, and thus, if possible, to constitute it further evidence, according to our canons, there is no substitute. However, such an excellent case of instant, adequate verbal adaptation to the real past will seem to many to vouch sufficiently for its psychic character, without further logical prop.)

Post-hypnotic Stage:

E: What do you remember of the past period? O: I don't remember anything; it doesn't seem like anything to me.

E: Do you recall anything? O: No.

E: Are you trying to? O: I don't see how I can try to recall.

An interruption occurred at this point (length unspecified in the record) after which E resumes hopefully.

E: *Now* do you recall anything? O: No (but see below).

E: Do you want to? O: (Slowly) I don't know.

E: What do you recall, then? O: I have a general feeling of great confusion.

E: Do you recall anything before the last hypnosis? O: No (but his next answer shows recovery).

E: Do you recall anything from the afternoon's work? O: Yes—about the fable—something with pencils (which he sees lying on the table and which he says look familiar); but I don't remember doing anything with them.

E: What did I show you? O: 29. (Correct, see Exp. 7.)

E: Anything else—any other paper? O: No—just 29 on it (incorrect).

E: Any paper with automatic writing on it? O: No (incorrect).

O's right hand feels prickly as if asleep and his face numb. "Feels confused, removed by suggestion in hypnosis," runs the record.

Probative character of this experiment: While reading a fable so attentively that he is able afterward to give the story correctly, O, having forgotten what he was told to do, is counting the number of lines in the fable, interpreting the result by a code already known to E, and expressing the meaning by two spoken words—of all of which he is unaware *immediately afterwards*. Later, he recalls the counting and the words as spoken, without access meanwhile to any source of information outside himself.

In the foregoing, the only weakness, according to our accepted canons of proof, is the absence of a test for awareness, *while the alleged co-conscious process was in operation.*

Associative relations among the several stages and subgroups: Hyp. 1 is not associated with the reading-group of Int., and there is no evidence that it is associated with the (hypothetical) problem-group, though of course the latter has been causally determined by it. There is, again, no evidence as to its association with Hyp. 2, but positive evidence that it is dissociated from Post-hyp. The problem-group is apparently dissociated from the reading-group, and there is no evidence as to its association with Hyp. 2 or later integration with the reading-group. It is entirely dissociated with Post-hyp., unless " something with pencils " be a vague reference to it. There is no evidence as to whether the reading-group is associated with Hyp. 2, but for its association with Post-hyp. the evidence is positive, although O forgets one fact, viz., being shown the paper containing his writing.

Comments: (1) The auditory disconnection, apparently complete except for the waking-cue and, possibly, the stimulus that sent him to the table, is the new fact of interest. It is more inclusive than in the other experiment of May 27, 1920 (Exp. 7). Then O could not think how to speak; now he cannot hear. Unfortunately no attempt was made, in the present experiment, to discover whether O could vocally answer visually presented questions, or hear other sounds besides speech. So we do not know whether merely speech from auditory cues, or perhaps all sounds, too, were inhibited; or the vocal apparatus also. The latter, if inhibited, was not carrying on separate activity, whereas the hearing-of-speech function was evidently so doing. This coupled with the writing has the appearance of being both psychic and co-conscious, and its scope of knowledge resembles that of the usual Hyp. 2, in which O communicates by speech. All the mind-expressing organs of the body except the writing-hand seem to have been in the service of an unusually limited psychic-group. Perhaps it was felt as a dreamy, negative state. The external appearance of O would indicate that as much as anything. But one glimpse into its content is in its accessibility to the auditory

cue of waking and, possibly, to an auditory one for going to the table. The writing-hand insists on the fact of co-consciousness—that he hears but he doesn't, that he feels touches but he doesn't—and in conjunction with evidence from other experiments this is of great importance. But, by themselves, the facts of this interesting Hypnotic State 2 do not conform sufficiently to our canons to be accepted as evidence. These flatly contradictory statements of O indicate that the stage in which he makes them is broad enough to include two states, otherwise dissociated, whose peculiarities, as dissociated states, are, nevertheless, known all together in this stage. (2) In Int. O's sleepiness seems to be curiously on the verge of suggestibility. He resists, yet wants to go to sleep, but he declares he won't, unless E wishes it. (3) The automatic writing occurred without verbal suggestion; but to place a susceptible person in position for writing is probably to give him a pretty definite visual-tactual-kinesthetic suggestion. (4) The dissociation of Hyp. 2 from Post-hyp. despite a definite suggestion that it be remembered, is noteworthy. This dissociation is nearly complete—everything gone but a "general feeling of great confusion." When told that he was to remember, he expressed serious doubt of his ability to do so, without knowing why it should be so difficult, but adding that he was asleep in a different way than what was usual for him in hypnosis. He was unable to characterize this difference. That this dissociation was in some sense motivated is hinted by his statement that he does not know whether he wants to recall the forgotten experiences. The problem of motivation versus passive disconnection is here opened up for all hypnotic dissociation. (5) The bodily members connected with the dissociated experiences—right hand and face—show an altered sensory state; the hand is now anaesthetic, now prickly; the face is numb. (6) When O in Int. declared that he felt he had been giving attention to the reading, the hand is apparently moved to some sort of resistance or modification of statement; but in its turn is subject to some inhibition that reduces the writing to an illegible scrawl.

EXPERIMENT 9.

(Three experiments in one.)

April 26, 1921, 2 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

The experiments here reported formed a part of a larger one designed to determine the means by which a hypnotized person could pick out, with almost infallible certainty, one sheet of blank paper from many other similarly blank sheets as the one on which he had previously seen a (suggested) portrait. It is included here because it seems, incidentally, to furnish evidence for coconsciousness.

HYPNOTIC STAGE 1:

E speaks: I am going to show you a card. On that card you will find a picture of Abraham Lincoln. Have you ever seen a picture of him? (O says "yes.") You will be able to open your eyes and still stay quite asleep.

A blank oblong of light blue cardboard, about two and one-half inches by four inches, was put into O's hands, his eyes being open. This card he had been unable to distinguish from other similar cards outside hypnosis.

E: Can you see the face? O: Yes.

E: Describe it. O: Side whiskers—looking straight at me.

E: How much of him is represented? O: Just the head and shoulders.

E: How do the eyes look? O: Looking straight at me—usual picture.

O then closed his eyes, while the card was inserted as one of a pack of ten similar cards, about seventh from top and right side up, behind O's back. The pack was handed to him, with directions to pick out the picture he had just seen. In one and two-thirds minutes, O said that he did not see it. Being asked whether he was deeply asleep, he nodded his head; and tests showed him to be fully suggestible.

He was then handed the same card as before, and was told that it was a picture of Washington.

E: Describe it. O: He has on a powdered wig; is looking a little to the right—a full-length portrait. He has on a Revolutionary coat and sword, buff colored trousers which are quite tight, shoes and buckles.

E: Have you seen a picture like that before? O: Yes.

E: Where? O: In an engraving.

The card was then placed right side up in the former pack, about seventh from the top, and O was asked to pick out Washington's picture. He examined them in order for one and two-thirds minutes; and on reaching the correct card he said 'I think this is it," and looked no further. The other cards, said he, were also pictures, and he called one Madame de Pompadour.

E: How did you recognize the pictures of Washington? O: I can always recognize his picture. It is full length. I didn't see any other of him.

E: How did you recognize the picture of Madame de Pompadour? O: I have just been studying it, (and he went on to give a full description—dress, books, globe, music, etc.).

These answers are pretty nearly what one would expect from a person who had really been looking at a portrait.

INTERIM STAGE:

E: Are you awake? O: Yes.

E: What has happened? O: I can't remember. The last thing I can recall is a feeling as though waves were rushing down over my head. They go farther and farther away—and then I woke up.

Sitting at the table (whether at E's request or spontaneously, does not appear in the record), with a pencil placed by E in his screened right hand, he began at once to write spontaneously. At the same time he discussed with E this experience of hypnotic induction, laughing and talking easily. He repeated the multiplication tables of twelves and elevens, going in the latter to 18 x 11.

E: Can you still repeat those verses by Amy Lowell with which you amused me last year (referring to "Gargoyles")? O: (laughing) I can't remember them.

E: Are you awake? O: (laughing) Yes, of course.

E: What are you doing? O: Talking with you.

E: What are you doing with your right hand? O: Nothing. I have a pencil in it.

E: What have you been doing with it? O: Moving it around; but I haven't been thinking about it.

E: Tell me when you feel a touch (proceeding with the test which showed that the writing hand was anaesthetic to the wrist). O: My hand feels asleep. (later) My hand is so asleep I can hardly tell. (He hesitated in making answers; and said usually: "I think you touched me.")

A test further showed that the writing hand was suggestible, though O felt that he was in full control in all parts. When the screened hand was brought once more into view, O felt all touches upon it while looking at it.

Meanwhile O's screened hand had been writing spontaneously. E moved the paper occasionally, and sometimes moved the hand into position, lifting it by the sleeve. Once in a while E, during his talk with O, looked at the writing and at the hand producing it. This method was followed throughout this experiment. The writing was as follows:

Washington . . . Mme de Pompadour portraits | . . . *Revolutionary coat* . . . | . . . | *brass buckles . . . on shoes* | . . . | *heavy white & gold* | *dress . . . globe to represent her interes* (E moved the paper here to start O on a new line) | *interests in books music I can always* | *pick . . . portraits . . . oranges* | . . . | . . . | *gold white . . .* | . . . | . . . *gold . . .* | . . . *white . . .* | . . . *dress . . .* | . . . | *Gargoyles A Comedy of Exag* | (After writing this title of a poem O began a new line spontaneously.) *Thimble . . .* |

The contents of this writing refer to the experiences of Hyp. 1, with the exception of the part beginning with "Gargoyles." Here the poem is not correctly named, "Exag," obviously abbreviated from Exaggeration, being substituted for "Oppositions." The first line is correctly started. Its occurrence here is apparently due to the question about it, put to O during this same Interim Stage and which he laughingly declared he could not remember. It is of course possible that the little he wrote was known to him in his dominant state, in spite of his declaration of ignorance; he was not tested upon this. The source of "oranges" is in certain suggestions made to test the depth of Hyp. 1.

Hypnotic Stage 2:

O was told to take his seat at the table on awaking, and write automatically, without being aware of it, the real basis of distinction by which he recognized the picture of Washington.

INTERIM STAGE 2:

In answer to a question O stated that he recalled nothing of Hyp. 2. Rising and moving toward the table he was asked why he did so. Because he thought he would, was the reply. At E's request, he recited some of Amy Lowell's poetry. He also gave an account of what he had been doing all day. Reciting with difficulty some college songs, he took part in a bantering, laughing conversation. He was asked, with reference to each hand and foot, in successive questions, whether E had moved it. He replied in each case: "I don't think you have." He was also asked, severally, what he was doing with each hand and foot, and to each question he replied "nothing." He was not suggestible except in his concealed right hand, which was also anaesthetic as far as the wrist. He declared that he felt all right in every part; and yet, when E placed two hands on O's two hands, O said his right hand felt asleep, and that he could not feel E's hand on it. Being asked as to whether he felt that he had good control of both hands, he replied that he was not sure, because his right hand was so fast asleep. Referring to Int. 1, he commented that he was not quite as usual; he was day-dreaming.

E: Are you now? O: No, but I have been while sitting here this time.

E: Why do you say so? O: I felt differently. I didn't think of it at the time; so the difference must appear only in retrospect.

E: Can you recall any of the day-dream? O: No.

The screen was removed. When O's eyes were closed, his right hand was still suggestible; when his eyes were open, he refused to obey, but with difficulty. At this time he wrote the following introspection:

"My eyes were closed and I was told to raise my left hand, which I did. Then I was told to raise my right hand (but told also that he could not succeed) which I also did, both hands being raised with customary ease. I was then asked if my hands were up, and I answered that of course they were. I was told to open my eyes; and much to my surprise, my right hand was *not* raised from the table. I thought at first that I could not believe my eyes, because my right hand *felt* raised just as much as my left hand, which actually was raised. Of course I finally had to believe my eyes; but the situation was very startling and confusing. It came down to which sense I would believe really, because feeling told me it was up, and sight that it was down."

Then E took up the questioning again:

E: What has been happening of importance? O: Talking with you.

E: You have been writing. What have you written? O: I didn't know that I was writing; so I don't know what I wrote.

Meanwhile his hand had been producing the following:

By seeing the marks | although I didn't know | it . . . | only by marks marks marks | marks marks marks | marks marks marks | marks marks on the paper paper | marks on the paper

This was the content of a single sheet. Much more was written to the same effect and with the same iteration but without further new ideas. All of it constitutes the response to the suggestion given in Hyp. 2. That the statements are true, that this is the actual basis for this well-known capacity in hypnosis, has been shown in certain unpublished experiments by E, of which the one now being reported constitutes a part.

HYPNOTIC STAGE 3:

E: Now I want you to tell me what you were doing at the table. O: Talking with you and writing.

E: What? O: How I told (recognized) the photograph.

E: How did you? O: By marks on the paper.

E: How can you remember now if you were not aware then? O: I don't know.

E: Did you know at the time, that you were picking out the picture by these marks? O: No.

E: How do you know now? O: Because that is what I wrote. I thought I was picking it out by the picture. I saw others beside the one desired.

E: Do you remember directly, now, how you did it? O: I don't think so—except by the portrait. I think I see the marks and then see the portrait right off.

E: Is this recalled from the original experience? O: No, I only saw the portrait then.

E: Why do you think so now? O: Because that is what I wrote.

E: Might you not have written what wasn't so? O: No.

E: Why are you so sure? O: You told me to write the reason; so I wrote it.

E: Were these marks easy to find? O: I don't remember.

E: Do you recall looking for any other beside Washington? O: Yes—Abraham Lincoln.

E: Did you find it? O: No.

E: Why not? O: Because he wasn't there.

E: How could you tell? O: Because so many were upside down, I couldn't tell.

E: What were upside down? O: The pictures.

E: What made you think them upside down? O: Because they looked that way. (This, of course, may have happened, but not intentionally, during the progress of the experiment. In the larger whole of which the present experiment formed a part, one, at least—the critical card—really was turned upside down, and possibly others.)

E: Were you trying to recognize Lincoln as you did Washington? O. Yes, by the picture.

E: You said you recognized Washington by the marks on the paper. O: I don't remember doing that.

E: When you waken you will write for me automatically the real reason why you failed to recognize Lincoln.

Interim Stage 3:

O went to the table without further direction and his hand began to write behind the screen. He said that he recalled nothing which had been going on; that he had felt asleep. At E's request, he named the states of the Union, forward and backward, using, he said, visual images to recall them; and he also named the Presidents but not in their order. Tests showed anaesthesia of the writing hand as far as the wrist.

E: What are you doing with your hand? O: Holding a pencil in it.

E: Are you awake or asleep? O: Awake.

E: Are you day-dreaming? O: While being touched. (The right hand was not the only part touched in the tests for anaesthesia.)

E: At any other time? O: Yes, pretty nearly all the time.

E: Is this different from your ordinary experience? O: Yes.

E: What do you mean by "day-dreaming"? O: Not being so aware of things around me, not so alert.

E: Lift your left hand. O does so.

E: (pressing his hand down over O's right) Lift your right hand. (E felt a little lifting movement under his hand but not much.)

E: Have you done so? O: Yes—one hand was raised as high as the other.

E: Is one hand as free as the other? O: Yes, so far as I can tell.

The writing was this:

I didn't notice the | marks on the . . . paper | . . . | . . . marks on the paper marks | nkansasn . . . marks | no marks . . . paper | . . . (This line to this point written from right to left) . . . *marks . . . | . . . marks on the | paper . . . paper . . . | no marks on the paper | like Lincoln's picture | . . .* (with right-to-left return of the foregoing toward the end) . . . *marks | on the paper paper |*

The truth of this statement, given in response to the demand for information on this point made in Hyp. 3, cannot, of course, be objectively verified, but is in accord with the basis of judgment in such matters, as already stated in this experiment, on the ground of experimental evidence.

The meaningless intrusion of a single state name out of the voice-group is puzzling.

HYPNOTIC STAGE 4:

E: What were you writing? O: The reason why I couldn't find Lincoln's picture (correct).

E: What was it? O: I didn't see the marks (that were) on Lincoln's picture (correct).

E: What sort of marks? O: Flaws on Lincoln's picture that I could see. I wrote that I found the photograph by flaws. I remember the flaws. (But he does not remember using them as a clue to the portrait. See below.)

E: Was what you wrote correct? O: It must have been.

E: Why do you say "must have been"? O: Because I don't remember that it was.

E: Do you mean that you had access to information when writing that you haven't now? O: I did before I wrote.

E: How much before? O: Just as soon as you told me to write it.

E: While you were hypnotized? O: Yes.

E: Did you at that moment actually recall? O: Yes.

E: Can you now recall? O: Perhaps.

E: Try. (then, after a pause) Have you succeeded? O: I can't think of it very well.

E: Now you can. O: Yes, I remember it now.

E: Remember what? O: How I found the portrait.

E: How did you find it? O: By the marks on the paper.

E: Were you aware at the time of how you were finding it? O: No.

E: Is it easier to talk of your experiences or to write of them? O: I don't like to think of them.

E: Why? O: Too hard.

E: Would you rather I didn't suggest that you remember them when you wake up? O: I don't care.

E: You will be able to recall these experiences easily, without effort. You will remember if you wish to.

POST-HYPNOTIC STAGE:

O felt more awake than ever. He recalled hallucinations from Hyp. 1; he remembered about writing (not the act—see below) but not what he had

written; he remembered telling about the content of the writing but could not recall where or how he got the information. He remembered telling, not writing, it. He recalled also being told to do various things—raise his hands, etc.

E: Did you feel much different at the table from the way you felt in the easy chair? O: No—not much of a breaking point between them.

E: What was the situation in the easy chair? O: I was hypnotized. At the table I felt more like myself but not quite. There was a feeling of oppression; I wanted to throw off something and be awake.

E: Do you feel that way now? O: No, I don't. In the Interim Stage at the table, when asked how I felt, I would say I felt awake the same as ever, and it seemed so; but just before and just after the question everything seemed hazy and not free.

E: What did you feel about the suggestions for hand movements? O: It seemed to me that I was executing the right-hand movements; but as I felt no good report from that hand I wasn't sure.

E: You don't usually remember these things when you come out of hypnosis. O: You told me to.

E: Do you care to? O: I prefer to.

E: How do you feel preference? O: In the Post-hypnotic stage the attempt to recall is disagreeable. (The term "post-hypnotic" presumably means here any one of the interim stages also.)

E: What was the difference, in and out of hypnosis, in the reasons for wanting to remember? O: In hypnosis, because you want me to remember; out of hypnosis, because I'm curious to know what took place. It is disagreeable even now to try to recall how I pick out the picture. (This was done in hypnosis, which, however, O declares below to be agreeable.) I remember about them but not the things themselves. I can remember telling you (*i.e.*, in hypnosis) how I did it but I don't want to remember the "how" itself; I am not remembering it now. I have often noticed this.

E: Do you think you could remember the "how"? O: Yes, I think I could.

E: Why is it so disagreeable? O: Because the original state (meaning as shown below, an interim stage) was so confused. While in that state I was not bothered by it. It seems muddled and unreal—not the way I usually think. It is much more agreeable to be hypnotized than to be in one of those interim states. In hypnosis you take things as they come; in the interim state you have to sort of keep awake. It is perplexing to think of things then which you are able easily to think of when hypnotized. (Yet, in Hyp. 4 he declared it was "too hard" to think of how he had picked out portraits in hypnosis.)

There is apparently some contradiction in O's comparisons between hypnotic and interim stages. These would all be resolved if we suppose that the open-eye hypnosis of Hyp. 1, in which O picked out portraits, was more like interim states than like his usual hypnotic experiences. His introspection seems to indicate that they felt more alike; and they have in common the important character of dissociation (or at least physical disconnection) of processes.

Probative character of this experiment: There are three parts to the evidence, corresponding to as many instances of writing, and taken here in their original order.

1. O spontaneously writes about matters of which he has previously been talking but has, in some sense, now forgotten. In this writing he also generalizes a little on the earlier situation ("I can always pick portraits") and starts to write—and correctly—other matters which he declares he has forgotten—all this, while in some sense unaware of his writing and while carrying on an animated conversation and repeating multiplication tables. No sufficient attempt was made to find out whether he could later recall what he had been writing.

2. In two instances, while occupied with other matters requiring attention, and not able to recall certain directions given to him, he carries these out, though in some sense unaware of his act; and in so doing contradicts his own earlier statement. Later he recalls this act and the content of his writing, without access, meanwhile, to any source of information outside himself.

Associative relations among the several stages and subgroups: The following summary gives the facts:

Hyp. 1, with Int. 1, hand-group only (Hyp. 2 not tested); with Int. 2, hand-group only; with Hyp. 3, according to O's assertion in Hyp. 4; with Int. 3, hand-group only; with Hyp. 4 and Post-hyp., each, at least in part.

Int. 1, hand-group; not with Post-hyp. (other stages not tested). Voice-group, with Int. 2, in part at least (other stages not tested).

Hyp. 2, with Int. 2, hand-group only; with Hyp. 3 (later stages not tested).

Int. 2, both groups with Hyp. 3 (Int. 3 and Hyp. 4 not tested); voice-group possibly, but not the hand-group, with Post-hyp. The contribution of this voice-group cannot be distinguished from the corresponding contributions of the next interim stage. Nor indeed can we tell whether each does contribute.

Hyp. 3, with Int. 3, hand-group only (Hyp. 4 not tested); with Post-hyp., possibly, but it is impossible to distinguish between the contributions here of Hyp. 3 and Hyp. 4, nor can we be sure whether each does contribute.

Int. 3, hand-group, with Hyp. 4; not with Post-hyp. Int. 3,

voice-group (Hyp. 4 not tested); with Post-hyp., possibly. See above.

Hyp. 4, with Post-hyp., possibly. See above.

In all the foregoing there was no aid to recall furnished intentionally by suggestion from E except in Hyp. 4 in two instances, one to take effect in that same stage, the other in Post-hyp.

From the foregoing facts one may conclude that, so far as tested, the several hypnotic stages were all synthesized in Post-hyp., and the voice-group of the Interim Stages was also; but that the hand-group of all the interim stages remained dissociated from the final synthesis.

Comments: (1) How much is the voice-group aware of the writing hand? The record of the three interim stages shows (a) that O was aware of holding the pencil (Int. 1 and 3; no test of Int. 2), (b) of moving it around but not thinking about it (Int. 1), (c) of doing nothing with it (Int. 2), (d) that this hand felt asleep (Int. 1 and 2), (e) that he had illusions of control over it (Int. 1, 2, 3). At no time was the voice-group aware of the meaning of the hand movement. (2) This experiment shows that for dissociation in interim stages no special suggestion that O will not know what his writing hand is doing is necessary. This suggestion was not given for the first interim stage and was given for the other two, yet in all three O was unaware that he was writing. (3) In all the interim stages there was motor dissociation (disconnection) of the writing hand from the voice-group. This function was restored to the voice-group again by aid of vision, but with difficulty (Int. 2). (4) Anaesthesia again characterizes the writing hand, and touch is restored when the hand can be seen (Int. 1). That is to say, touch is integrated with the voice-group once more by aid of the visual function. (5) Felt characteristics of the interim stages—dreaminess, haziness, lack of freedom, oppression, sense of something to be thrown off—disappear at once before the question, "Are you awake?" but return immediately after answer has been given. (6) O's statement in Hyp. 3 implied that Hyp. 1 was a double state, *i.e.*, one of co-consciousness; but being further questioned, it appeared that he did not recall directly a second group of experiences but

only his writing about that group, just as, later, he was able to recall not the writing but only telling about it.

EXPERIMENT 10.

May 3, 1921, 3:15 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

(See introductory note to Experiment 9.)

HYPNOTIC STAGE 1:

O is told that he will be shown a card on which will appear a portrait of Washington (the card, of course, being blank). He remarks that he knows Roosevelt's portrait better. So E hands him a (suggested) picture of Roosevelt instead. O describes the portrait. This card is then put aside down into a small pack of similar blank cards, and O fails to find the portrait again. E gives him the same card again, in the original position, asking whose portrait it is. The record of the reply is as follows: "O answers George Washington. This is Roosevelt, says O—about like the other, but in this one hasn't glasses on—did in the other—suggests, himself, pictures on the cards—McKinley, Wilson, Harding. Correct judgment given in 40 Sec. Card D (one used in the earlier Roosevelt experiment. C. T. B.) was used again, not reversed." From the tenor of this statement and of the following dialogue, it seems warrantable to doubt that R has inserted Washington in the correct place in the record. O's recognition of other portraits was due to E's suggestion that he do so;—O remarking that it seemed to be a series of the Presidents; and occasionally passing over one as not identifiable.

E: How did you recognize Roosevelt? O: By his features, especially his smile.

E: What were you thinking of between times? O: Presidents, I guess.

E: Are you sure you recognized the pictures by characteristics of features? O: Yes, the same as any picture.

E: When you waken, go to the table and write for me the real basis by which you distinguished the picture of Roosevelt. You will be unaware that you are writing and will be able to converse meanwhile.

INTERIM STAGE:

E: What do you remember? O: Good nap (going to the table and sitting down), just like being asleep. (It is an error, perhaps, that O was not questioned further on this point, to make sure he could not recall.)

He describes the feeling of on-coming hypnosis; his inability to recognize its arrival. Meanwhile his right hand is writing. He describes further, how he goes to sleep; then—spontaneously—what he did the night before,—the dreams he had, etc. He converses rapidly, easily, entertainingly. Once early in the writing, in a pause of the conversation, he had a far-away look.

E: What have you been doing? O: Talking about dreams, describing how I go under hypnosis, etc.

E: Was anything else happening? O: No, only your touching me. (This, presumably, refers to check tests on other parts of the body. Tests for anaesthesia of right hand had been positive as far as the wrist.)

E: Are you awake or asleep? O: Awake.

E: Sure? O: Yes.

O has no control over the writing hand, but over his other limbs he has.

For example:

E: (in a loud and confident tone) Now, you are going to lift your right hand (which is, of course, behind the screen). (O obeys.)

E: Now you can't put it down. O: Yes I can (but he does not).

E: Are you awake? O: Yes, sure!

O says that his hands are cold, that he can't feel with his right hand, though he can with his left. When E takes the screen away, O regains control. Now follows a test of suggestibility, the right hand being visible to O.

E: You have to scratch your ear with your right hand. O: (scratches it with his *left* hand. He says that he must look at his right, to make sure it doesn't scratch the ear; he doesn't dare look away. But he succeeds in refraining.)

E: Is your hand all right now? O: (Finds it numb.)

E: What was on the table? O: Paper and writing. (This had been carelessly left in view when the screen was moved, apparently without actual harm to the experiment, as shown by O's next reply, but regrettably bungling.)

E: What was the writing? O: I don't know. I thought you wouldn't want me to read it. I had no inclination to do so; didn't care what it did say.

O is then told to put his right hand again behind the screen; he does so and shuts his eyes.

E: You can't lift your right hand. O: (Hand does not rise.)

E: Did you do this (*i.e.*, lift your hand)? O: Yes.

The screen being removed, O reports that his right hand is numb again. During the foregoing events of Int. the following writing was produced. It was interrupted, partly by tests for anaesthesia, partly because E did not allow further opportunity for trial.

. . . I chose the picture | of Roosevelt | by the marks marks | marks marks marks | marks | by the mark by the marks | Roosevelt, McKinley Roosevelt by the marks marks | by the marks | marks by marks | Washington | McKinley Roosevelt grant | . . . | McKinley no picture | Roosevelt Roosevelt | Roosevelt McKinlyey | Roosevelt . . . |

Hypnotic Stage 2:

E: What were you doing at the table? O: Talking to you about dreams. You were touching my right hand.

E: Did you know it? O: Not then.

E: How now? O: Don't know. Perhaps I knew it then but didn't think about it.

E: Were you aware then when I touched your right hand? O: Yes, I knew it.

E: But you didn't say so. O: (hesitates) Don't know.

E: What does that mean? O: I've forgotten the question.

E: (Repeats the question.) O: I didn't know it then but do now.

E: When did you get the information? O: I remember it now.

E: Remember it now and not know it then? O: Yes.

E: Does this seem contradictory to you? O: You told me I wouldn't know I was writing.

E: Does this seem contradictory to you now? O: No.

E: You could raise your left hand, though. O: You didn't tell me anything about my left hand.

E: Did your right hand obey you or me when suggestions were given? O: When I wasn't looking at it, it obeyed you.

E: Was it obeying you the rest of the time? O: Yes.

E: How could you tell? O: Felt as though it was.

E: How could you feel it was obeying you and yet know it wasn't? O: (hesitating, a look of troubled effort on his face; then after a long pause) I forgot the question.

E: Did you notice what I whispered to R? O: No.

E: How could you feel that your hand was obeying you and yet know that it wasn't? O: I didn't know that it wasn't.

E: How do you know now? O: Part of me must have known, because I can remember now, though I didn't know then; that is, I didn't think about it when talking to you.

E: Were you the part that was talking to me or the part that was writing? O: The part that was writing.

E: Who was talking to me? O: That was—(hesitates) I don't like to talk about that.

E: Why not? O: I don't like to think it was anybody else.

E: Did you feel quite natural while talking at the table? O: I don't know whether I was talking to you or not.

E: You don't remember how you felt? O: *I* felt all right.

E: Who was talking to me if not you? O: (Silent. The record adds "uncomfortable, O says, doesn't like to think about it.")

E: Do you want to remember about this when you waken? O: I don't care—yes.

E: Was it true when you said, on waking formerly, that you didn't remember what happened? O: Yes—*I* knew about it, though.

E: And that wasn't you? O: (after an effort) Yes, that was me. The suggestion is then given to O that he will remember on waking.

Post-hypnotic Stage:

E: What does your present state seem like? O: Waking up from a nap. Not so clear as I usually am on waking up,—a dazed feeling, like when you wake up suddenly.

E: Do you recall what has been happening? O: Pictures of Roosevelt and Washington—Roosevelt's twice (correct).

E: What happened more recently? O: You told me to write at the table. I don't know what went on then—something about dreams. I don't remember these things so well. Then you asked me if I had been writing at the table (really, what he had been *doing*). I can't remember other things except confusedly. I remember telling you about writing but not the writing itself. I remember your asking me questions about it but not just what they were. (Correct answers with the exception noted above.)

E: Do you now recall it? O: You asked me how I could write (really, feel the hand was obeying and yet know it was not) and not know it; but I have forgotten what I told you.

E: Can you tell me now? O: No, not by introspection. It seems as though first part of hypnosis was smooth and clear; then it became very confused. I don't feel as if I wanted to remember.

E: There is no other quality of this last hypnotic period that you can recall? O: I feel as if it was not very pleasant. I don't like snarled up things.

E: Would you like to recall all? O: I don't want to make the effort.

E: If you could without effort, would you like to? O: Don't know, sometimes I think I would, then that I wouldn't.

E: Did the last hypnotic state feel deep? O. Yes. After such I usually recall that something has happened, but not precisely what.

As the foregoing experiment failed to show later knowledge of the original contents of the writing and as our canons of proof required this to be shown, a supplementary inquiry was undertaken on the same observer two days later (May 5, 1921, 2.00 P.M.) The original comment on the record, made close to the time the record itself was produced, states that he had, meanwhile, no access to outside sources of information; but it neglects to state how E was assured of this. In Hyp. 1, O was approached as follows:

E: I want you to recall for me what you wrote at the table a few days ago. O: Didn't know I was writing.

E: What did you write about—what was the content of the writing? O: What you had told me to.

E: What was that? O: How I picked out the picture.

E: How did you? O: By—(hesitates) the marks on the paper.

E: Do you remember what words you used? O: By the marks I picked out the picture of Roosevelt. (The original statement ran: I chose the picture of Roosevelt by the marks.)

E: Did you use these phrases? O: I think so—hard to remember.

E: Do you remember anything else you wrote, if anything? O: Something about Washington. I wrote by the marks two or three times because I wanted you to understand. (The objective facts here stated are correct but understated.)

E: Try again to remember anything else you wrote. O: I wrote Lincoln (this may perhaps be the final illegible word); and by the marks three or four times.

E: Have you heard anything I have said to George? O: I heard it but paid no attention to it; I didn't think you were talking to me.

E: Can you tell what was said? O: Once you said: "Did you get that?" and then: "Is this going too fast for you?" I don't think I heard anything else. (He speaks very slowly, knitting his brows and compressing his mouth—characteristic of him in hypnosis in this experiment and that of May 3, 1921.)

E: Can you tell what George has said in reply to me? O: Once he said: "What was that after that last question?" and once he said "yes"; and once he said "Yes, I've got that." I don't think he said anything else—yes, he said "What?" once or twice.

E: What are you thinking of now? O: Not thinking.

E: Having any experience at all? O: No—answering questions; and I can hear you asking questions and some one else speaking (voices from below).

E: Any spontaneous thoughts of your own? O: No.

Probative character of this experiment: O writes comments, pertinent and according to a plan, concerning his own earlier actions. He is in some sense unaware of so doing and, at the same time, engaged in animated conversation. Later, without access to outside sources of information, he is able to report with little error leading features of the content of that writing.

Associative relations among the several stages and subgroups: Those of Hyp. 1 to later stages were not, so far as the record shows, fully investigated. A general statement of O, which, on its face, includes the present case, seems to justify the statement that vague associative relations persisted with the voice-group in Int. With the hand-group, the connection was close, also with Hyp. 2, though the breadth of connection here was not investigated; and, by suggestion, close connection persisted with Post-hyp. Int. showed mutual dissociation between the partial groups, these in turn being partly reunited in Hyp. 2. By suggestion the voice-group persists in Post-hyp., but the hand-group disappears unless it be as an awareness of a mere somewhat. Special items of Hyp. 2 are associated with Post-hyp.

Comments: (1) In some way O felt that he was controlling the movements of his right hand; yet he knew later, without information from anyone else, that he was not. In some way, too, he could feel no touches on his writing hand, but afterward knew that he had been touched there. (2) Ordinarily such a question as, "What have you been doing?" is sufficient to call one's attention at least to the unusual features of one's conduct. Not so in this case in Int. (3) It is interesting to see the "struggle" of the visual function to retain in its group the right-hand-tactual function. When the right hand passed from view its tactual functions became at once dissociated. In the struggle the left hand seemed to assist by taking the suggestion given to the other. Even when the right hand was made visible its tactual-kinesthetic function was altered; it felt numb. Is this an associated sensation, appearing because usually accompanying this type of situation? The hand also felt cold to O. There is no indication in the record that this was tested. It was, however, not improbably an objective fact, for E noted that at least one other observer's writing hand seemed quite cold to E's touch. So it may be that the felt numbness had a peripheral basis. (4) The writing contradicts the statement made in Hyp. 1. In the latter O asserted that he recognized the pictures by characteristics of features "the same as any picture"; in writing, "by the marks," "no picture." (5) Hesitation, troubled effort, silence

were characteristic behavior of O when he tried to face the apparent contradictions in his introspection. (6) One may remark on O's apparent indifference, in hypnosis and the Interim Stage, to what he does not think is meant for him.

EXPERIMENT 11.

May 18, 1921, 2:45 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

The following directions were given to O: When you waken you will sit down at the writing table. I will show you a number on a piece of paper. If it be in ink of one color you will make automatically for each digit a corresponding number of circles, in a row, row under row; if in ink of two colors, use crosses for red ink digits and circles for those in black. Otherwise proceed as in the other case. (These directions were repeated; and then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

O goes to the table and sits down, putting his hand behind the screen spontaneously, as both he and G. E. H. do regularly in such cases.

E: What do you remember? O: Nothing.

E: Is it a blank? O: Not quite. I feel as if something is there.

E: What is the difference? O: As if something is there. I don't know what.

E: Is it like a forgotten name? O: I have no desire to think of this. I am annoyed to forget a name; but not this.

E: Can you say the multiplication table of 9's? (O does so.)

E: (showing O a card bearing the number 724, the 2 in red, the others in black) What's that number? O: 724.

E: What is its meaning to you? O: Nothing; just 724.

E: Does it remind you of anything? O: No. I think I had a key like that once (with doubtful smile).

E: Is that all? O: Yes.

E: Can you describe the present situation? O: I am sitting in a chair, talking to you. You showed me a number, meaning nothing, in two kinds of ink. I've been trying to describe what I was thinking about.

E: What else went on? O: George (R) writing at the table—nothing else.

E: (who has been making some movements behind the screen) What do my actions make you think of? O: Asking questions, showing me numbers, looking behind screen.

E: What does looking behind the screen make you think of? O: That I might be writing.

E: What is your right (writing) hand doing? O: Nothing.

E: Can you catch it in anything? O: No.

E: Your left hand? O: Yes, if I were doing anything with it.

E: What do you hear? O: (who is actually making perceptible scratching noises with the pencil, while writing) Train moving, batted ball, George writing, his chair creaking, minor noises. I could identify them if I tried to—rustle of clothing, etc.

E: What are you doing with your right hand? O: Nothing.

E: Do you surmise that you are doing something? O: Yes, that I am writing, because I have done it before.

E: Do you feel it doing anything? O: No.

During the foregoing conversation O was writing as follows in an irregular, cramped hand:

I am to make the I (written before the number was shown. Then follows, in strict accord with the original suggestion, in three rows under each other, seven circles, two crosses, and four circles. Then the writing continues.) *Circles for black numbers | and crosses for red ones | in parallel rows. If in one . . . |* (new sheet) *If one colors I am to | show and if two colors I am to make . . . |circles crosses circles & crosses | There are two colors ci | circles & crosses different color of ink | crosses . . . crosses*

One should observe that the statements made in the foregoing writing are correct; also that an interesting substitution of the appropriate word "parallel" has been made for the phrasing used in the original directions.

Tests now made for anaesthesia are positive on the writing hand even half-way up that forearm and beyond. O's manner of acknowledging the stimulus in that region in comparison with other parts of the body, is slow, hesitant, indicating that he barely feels it, as the following exchange shows:

E: Why the difference in tone when saying yes (word used to acknowledge a felt stimulus)? O: Sometimes you touch so lightly I hardly know whether you are touching or not. (Needless to say, this was not an objective difference.)

E now proceeds to determine whether stimuli on the anaesthetic area can be shown to produce in O conscious effects of whose origin he is unaware.

E: Please settle back quietly and tell me what number comes into your mind. Think of counting up the units that make up some number, for example, 1-2-3-4-5-6 for six, 1-2-3-4 for four, etc. Then tell me what number comes into your head.

Touching with the blunt end of a pencil the anaesthetic hand, in each case, the intended number of times, E used the following series: 2, 3, 5, 4, 7, 1, 6, 9, 8.

O: First number I thought of was 13.

E: When? O: A few minutes ago. (In this case enough time had elapsed before the stimulus was given to permit a choice in advance. The stimuli were given more promptly thereafter, at the rate of about three in two seconds.)

E: Think again. O: 9.

E: Again. O: 7.

E: Once more. O: 4.

From this point O's replies agreed with the stimulus. Once during the series, a query or perhaps a mere glance from E that meant curiosity as to the source of these numbers, made O say, "Any object to take numbers from, —as when George tapped his pen against his head."

At the conclusion of the series a test for anaesthesia of the right hand was positive. Then occurred the following conversation:

E: Where did you get the numbers? O: All sorts of places—some just thought of.

E: How did they appear in your mind? O: Association. Was trying to think of numbers—lucky 2, unlucky 13. Don't know how the rest came—sometimes from George's motions—not consciously though.

E: Did you have any sensory imagery with the numbers? O: Don't remember. Don't think so. May have been, but I don't remember now.

E: Do you recall anything else of significance to report? O: No. (E insists.) O: I can remember something but—

E: What was that? O: I imagined the numbers as little white dots representing units of numbers. I'm not sure I had this at the time though.

E: Shake hands with me. (O would of course naturally use his right, *i.e.*, anaesthetic, hand.) Have you? O: Yes (incorrect).

E: How does your hand feel to you? O: Normal.

E: Tell me when I touch your hand. O: It feels numb. I can't tell when you do or don't.

E: Lift it. (O obeys.)

E: Now you can't lift it. O: Yes I can (but he doesn't).

E: Now every time you try to lift your hand it will go down. Now where is it? O: In the air (incorrect).

E: Are you awake or asleep? O: Awake (and he refuses suggestions directed to his left hand. The right hand is still anaesthetic.)

E: You can't keep your right hand down. Are you? O: Yes (incorrect).

The screen was then removed, whereupon O's right hand was no longer suggestible, in spite of E's insistence. O, however, made obvious efforts to resist, keeping an intent gaze on the hand and rubbing it with the other. When he looked away, it yielded to suggestions again.

E: How does your hand feel? O: Kind of numb.

Being placed once more behind the screen, the hand again obeyed. O then returned to the easy chair.

E: Do you feel quite awake? O: Yes, but sleepy.

Hypnotic Stage 2:

E: Now tell me what you were doing at the table. O: Writing.

E: What? O: What you told me to do.

E: What was that? O: I was shown a number. If it was in ink of one color, I was to make that number of circles across the paper; if two colors, circles for the digits in black ink, crosses for those in red across the paper.

E: What was the number? O: 724.

E: Of what color the ink? O: 7 and 4 black, 2 red.

E: What did you write? O: Seven circles and two crosses below that and then four circles.

E: What else? O: Wrote crosses and circles several times.

(All the foregoing answers are correct.)

E: Anything else? O: Couldn't write all I wanted to.

E: Why? O: Hand wouldn't write everything I wanted.

E: What did you want to write? O: All the instructions you gave me.

E: Why couldn't you? O: Because I couldn't make my hand do what I wanted it to do all the time.

E: What prevented? O: Because I was trying to prevent it.

E: Trying to prevent what? O: I thought it must be doing something though I didn't know it at the time; and so I tried to keep it from doing it.

E: Did anything else happen to that hand? O: Yes, you touched it several times, sometimes with your hand, sometimes with something sharp, but I didn't know, at the time it occurred, that you touched me.

E: How, then, can you know it now? O: I remember it now.

E: What are you thinking of now? O: Nothing.
E: Are you asleep? O: No.
E: Do you feel in good control of yourself? O: Yes, if you want me to have control.
E: What if I don't? O: Then I don't want to.
By direction of E, who gave it unobtrusively, R here undertook to make suggestions to O, telling him to raise his hands. O did not obey.
E: Did you hear that? O: I heard something, but I didn't pay any attention to it, because I didn't think it concerned me.
O now followed E's suggestion, which was a repetition of R's.
E: Does this feel like ordinary waking? O: No.
E: How different? O: More comfortable, care-free, no extreme of any kind.
E: What does matter to you now? O: Nothing but what you want me to think of.
E: Was your right hand under your control at the table? O: No.
E: Why not? O: Because you didn't want it to be.
E: How did you know that? O: By the way you spoke.
E: Were you aware of that at the time? O: No.
E: Did you make a serious effort to recall at the table? O: Yes, but I didn't feel like thinking about things. I tried to, but really didn't want to.
E: Was it a really serious attempt? O: Yes, because of the difficulties I had to overcome.
E: What were the difficulties? O: Can't explain them.
E: Were you awake at the table? O: Not wholly.
E: Was that experience like anything you know in real life? O: Very much like waking in the morning. Seems as though part of my body belongs to someone else, though I could control it if I wanted to.
POST-HYPNOTIC STAGE:
E: Do you recall anything that has been taking place? O: Not a thing. (E insists, but O also persists.)
E: Does the table recall to you anything that has happened this afternoon? O: (Hestitates) I think I have been over there before, during this afternoon, but I didn't think of it till you spoke of it.
E: What is the most recent thing you can recall? O: I can't say I recall the table; not sure I was over there—might have been. The last thing I can remember is "relax completely" (a direction given by E while inducing Hyp. 1).

Probative character of this experiment: O selects and employs pertinent facts according to a plan, and writes about it; he also notes peculiar qualities of a touch stimulus; while in some sense unaware of it all and engaged in conversation and other mental employment ordinarily requiring much attention. Later O recalls it all without, meanwhile, having received information from any source outside himself.

Associative relations among the several stages and subgroups: Hyp. 1 has a very slight connection with the voice-group of Int. and full connection with the hand-group; but, so far as the evi-

dence goes, without connection, unless indirect, with any later group. In Int. the hand-group is dissociated from the voice-group except that, under special conditions of mental set in the voice-group, a few stimuli belonging to the hand-group cause images within the voice-group. The two groups are united, at least to an important extent, in Hyp. 2. (The record shows no complete testing in this stage for all the items of each group of Int.) Post-hyp. shows a very slight connection with Int. and no other.

Comments: (1) The scope of the dissociated hand-group is to be noted. Included with it is a considerably greater touch-area than in the case of Observer H. Certain auditory items are split off with it. (2) The usual methods of directing attention, ordinarily effective, do not suffice to reunite the two groups. (3) The automatic writing was to a large extent spontaneous, *i.e.*, it functioned beyond the scope explicitly assigned by suggestion. (4) There is motor as well as sensory dissociation between the subgroups of Int. The voice-group is "deceived" as to its success, both in moving and in preventing the movement of the special motor organ of the hand-group. (5) The voice-group can "feel" stimuli in the right hand when they do not exist, as well as fail to feel them when they do. (6) Vision, as a function of the voice-group, brings back the missing right-hand-touch function. (7) The attempt of the voice-group to control the right-hand function brings into evidence new sensory items from that hand, viz., numbness, which persists even when vision restores it somewhat to the control of the voice-group. (8) Int. is felt as a sleepy stage. (9) O recalls that stage as one of cross purposes, inner opposition, and defeat, but as lacking at the time any insight into its own meaning. (10) The abnormal character of the subgroups is shown by the susceptibility of both to suggestion. (11) The indifference of O to his incapacity in Int. is like that of the hysteric for his lost functions.

EXPERIMENT 12.

May 18, 1921, 4:15 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

HYPNOTIC STAGE 1:

Directions to O: On awaking you will go to the automatic-writing table. I will show you a piece of paper containing two numbers. You will perform the division of these numbers, the larger by the smaller, if they are given in ink of one color; the subtraction of the smaller from the larger, if in ink of different colors. Write the answer automatically. (The directions were repeated; and then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

O goes to the table.

E: Do you remember anything that has just taken place? O: No, I don't remember anything that has happened.

E: Are you quite awake? O: Yes.

During the foregoing conversation O is writing the following: *answer a problem of division or | subtraction.*

E: What is that (showing a card containing the numbers 27 and 9, both in black ink)? O: 27 and 9.

E: What does it remind you of? O: The last experiment (with another observer on the same afternoon).

E: What do you guess about it? O: I guess I am to perform some sort of a problem; but I don't see how; for in the last experiment there was only one number and there are two in this.

During the foregoing conversation O's right hand has produced the following arrangements of digits in a space 2⅝ x 1¾ inches.

3	3	3	3
3	3	3	3
3		3	3
3			3
3			

The lowest 3 in the left column was written last; it was fused with the first word of the next sentence written. This makes it probable, in default of any notation by E in the record, that these digits were produced in rows rather than columns. The regularity of the resulting figure was very nearly as precise as in this printed reproduction. The writing continued as follows:

I am dividing 27 by 9 be | cause they are the same | color but I don't know it.

Here are given correctly both the solution of the problem and its statement.

A test now made for anaesthesia of the writing hand was positive; but with this variant: Whenever any other part of the body was touched in this test O said yes; whenever the writing hand was touched he said nothing and gave no sign of perceiving it, except that the stimulated hand would make each time a vertical mark, arranging these in a row. This was done spontaneously, so far as E is aware.

A test was now made to see whether stimuli on the anaesthetic hand could be shown to produce in O conscious effects of whose origin he was unaware. The hand was touched with the blunt end of a pencil the intended number of times, at the rate of about three in two seconds, according to the following series: 7, 3, 4, 1, 9, 2, 8, 6, 5.

E: I want you to think of a one-place number. Think of counting the

units in it thus: one, two, three, four, for 4, etc. O: I thought of 7 (correct), but probably because it was the first number in the last experiment (which was a fact—724).

E: Think once more please. O: I thought of 3 (correct).

E: Why? O: Because, perhaps, 4 from 7 leaves 3.

E: Think again. O: All that seems to run in my head is that combination.

E: What? O: That 724 combination.

E: Think of a single one. O: 4 (correct).

E: Think of another. O: I don't think of any special number.

E: Think again. O: No one number.

E: Single digit. O: I might say 4 (incorrect, a repetition of the preceding).

E: Once more. O: 9 (correct); 7 and 2 make 9.

E: Once more. O: 2 (correct).

E: Why? O: Because it's another one of those numbers (724).

E: Try again. O: I don't think of anything.

E: Try again to imagine. O: 7 (incorrect).

E: Again. O: 6 (correct)—one I hadn't mentioned, so I thought I might as well try it.

E: Again. O: 5 (correct).

E: Why? O: 2 from 7 leaves 5 (harking back once more to 724).

E: What have you been doing? O: Thinking up numbers.

E: Is that all? Can you guess that you were doing anything you haven't mentioned? O: I might be writing, because that is what I generally do when I sit here with my hand behind the screen.

E: Have you been aware of it this afternoon? O: No.

E: Are you awake now? O: Yes.

E: As much awake as when acting as clerk (recorder)? O: Not quite so much awake because I've just been asleep (referring to Hyp. 1).

E: What are you thinking of? O: Nothing at all.

At this point, for the four questions following, the record becomes obviously an incomplete picture of the experiment, but cannot well be omitted. (See record of Hyp. 2 for what should presumably have been entered here.)

E: Can you put both hands down? O: I think so.

E: Why do you say "I think so"? O: Because I wasn't thinking of whether I was putting them down or not.

E: I am going to shake hands with you. Are you now shaking hands with me? O: I don't think I am.

E: Do you feel my hand? O: No.

Meanwhile there has been more writing produced spontaneously. It has been scattered over the period elapsing since the test for anaesthesia was made. Here is the record:

Seventhree . . . | . . . | one | nine | what a | what a | Give to . . . | two to . . . ix | no I don't feel as awake | but I can't tell of course | I don't know | awake I don't | why I don't fe . . . |

Here are fragmentary references to the original problem, to an occasional question, and to some felt inhibition.

E: Write your name now. Have you done so? O: I don't think so (but he has).

E: Now you will tell me whether you have written it or not. Have you done so? O: No (hand writes "yes").

E: Now you will write whether your last answer (*i.e.*, oral answer) was correct. Have you done so? O: No. (Hand has, however, written "No.")

A test for anaesthesia of the writing hand was made about this time, O's eyes being closed.

E: Do you feel that you have good control over both hands? O: No.

E: Where is your control least? O: In the right arm.

E: Can you do what you want to with it? O: No.

E: Why not? O: Because I don't feel it.

E: Write the name of this state and regain control of your right arm. (O writes "Maine.")

Whether control was thereby regained does not appear in the record; for in answering the questions just preceding, O began to appear so obviously passive that a new hypnosis was suspected. Being told to open his eyes he, at first, remained passive; but, after repeated suggestions, he conformed.

E: Are you now awake? O: Yes.

E: What is the last thing you remember? O: You were touching my hand several times. (This perhaps locates the onset of hypnosis in the foregoing record.)

E: Do you recall anything about the right hand? O: No.

This amnesia indicates that O did fall spontaneously into hypnosis while being tested for anaesthesia. The different tenor of his replies here is thus accounted for. The following questions were asked with the intent to test O's present degree of suggestibility.

E: You won't understand what my next question means. What did you have for dinner to-day? O: We had——

E: Are you sure you can remember? O: I can tell you if I can recall.

E: What? O: Eggs (correct, according to R).

E: Now rub your hands over each other. Do you feel awake? O: Yes.

E: As much as when acting as R? O: Just the same as when you asked the question before.

(O had evidently recovered from his brief spontaneous hypnosis.)

Hypnotic Stage 2:

E: Tell me, please, what were you doing at the table? O: Writing different things for you.

E: What did you write? O: 3 which was the answer to the problem.

E: How could it be? O: How could it be anything else?

E: How did you get it? O: Divided 27 by 9.

E: Why divide? O: Because the ink was of one color.

E: What else happened? O: I wrote what I was doing and answers to questions you asked.

E: Did you know you were doing it? O: No.

E: What else happened? O: That was all that I wrote—just answering questions.

E: Any other experiences received by right hand? O: Yes, you touched it, raised it, made it go from side to side.

(A part of the record above indicates that this may well have been true, but the record does not note it specifically.)

E: What kind of touches? O: Sometimes with something very sharp, sometimes with finger (correct).

E: Were you aware of this at the time? O: No.

E: What happened when your eyes were shut at the table? O: I was doing various things for you.

E: Were you in the same sort of state as just before and after that? O: I think so. You said to wake up and I opened my eyes.

E: Were you awake while at the writing table? O: No.

E: Were you asleep? O: No.

E: How describe the state? O: I didn't know very much.

E: What do you mean? O: I didn't think of anything and couldn't think of many things.

E: Are you awake or asleep now? O: I'm not asleep.

E: Do you feel as you do ordinarily during the day? O: No.

E: What is the difference? O: More comfortable and know more.

E: Know more? O: Yes.

E: What do you mean? O: I can remember about things I don't usually.

E: Can you illustrate? O: I can remember picking out portraits one afternoon, then writing about them, describing them. (This is a correct reference to a former experiment and events that occurred during hypnosis. The record shows no attempt to test O's ability to recall them outside hypnosis.)

E: What are you thinking about? O: I was thinking about what I was telling you about.

E: What was that? O: Picking out portraits. I remember last year not being able to speak, and writing you about it (all of which really occurred as O states, in hypnosis).

E: Don't you remember it when awake? O: I only remember *about* it; I don't remember *it*. (O had had plenty of opportunity to learn about this outside hypnosis.)

Here R attempted to make motor suggestions. No response.

E: Why don't you do that? O: Because I don't want to.

The same suggestions now made by E are accepted.

E: Why do you do it now? O: I want to.

E now gives O the suggestion that he cannot lower his raised arm, though trying hard to do so. This is accepted.

E: Tell me about your effort in trying to put down your arm. O: It won't come. I've forgotten how to do it.

E: To do what? O: To put it down.

E: Now you can tell how to do it. (O then lowered his hand.)

E: Can you recall answers to any other questions at the table? O: Yes, I put down a mark every time you touched me, to show you I knew you did it.

E: Do you recall anything else? O: You told me to write yes or no to certain questions. You told me to write my name and whether my answer was right.

E: Was your answer right? O: What I wrote was right.

E: Was what you said right? O: No.

E: Was it said truthfully? O: Yes, but I am so stupid I never know what is right and what isn't.

E: Do you know what I have been saying from time to time to Joe (R)? O: No, I haven't noticed.

E: Why? O: Because you haven't been talking to me.

E: Does your mind feel clear now? O: Yes.

E: Clearer than when at the table? O: Yes.

POST-HYPNOTIC STAGE:

O remarks on awaking, that he seems to have been more fast asleep than usual.

E: What do you recall? O: Nothing.

E: What is the last thing you recall? O: Sitting in the easy chair.

E: Does the table recall to you anything? O: The last experiment (*i.e.*, one with another observer on the same afternoon).

E: Does it recall to you any of your own activities? O: Yes, it does.

E: Those of to-day? O: No.

E: Do you recall anything else from to-day's events (*i.e.*, belonging to this experiment)? O: No.

E: What is your general attitude toward what has gone on to-day? O: I don't care. I don't want to have to remember it, but would like to have it told to me.

E: I will help you to recall. O: I don't think I want to.

E: Why? O: It's like recalling a nightmare—too complicated for trying to remember.

E: Does this mean that you have a disinclination for this experiment? O: No. When I wake up I feel relieved as though purged of terrible complications.

E: Have you ever, when not here, revived in memory any of these experiments? O: No. I never recall the actual experiences. I think of the results.

Probative character of this experiment: O gathers and interprets data and uses them to solve a problem—all according to a plan. He gathers other information, writes comprehendingly about the situation, and executes suggestions. Of all the foregoing functions he is in some sense ignorant. Yet afterward he is able to recall them all, without having received information, meanwhile, from any source outside himself.

Associative relations among the several stages and subgroups: Hyp. 1 seems to have no direct associative relations with any later stage. Int. shows the following: The hand-group is dissociated from the voice-group completely except that stimuli belonging to the former produce uncomprehended effects in the voice-group. The voice-group, on the contrary, seems to be pretty closely associated with the hand-group. Both are reunified in Hyp. 2, and persist by the scantiest associations into Post-hyp.

Comments: (1) O rationalizes falsely about the origin of certain experiences. (2) Stimuli belonging to the hand-group produce, in the voice-group, under conditions of appropriate mental set, effects whose real meaning in terms of external cause is not felt; and this is shown in eight trials out of ten. (3)

There is unusual spontaneity in the writing, expressing in a variety of ways the impulse to communicate. (4) The associative appropriation of voice-group by hand-group, without the reverse, is clearly shown in the writing. (5) Int. is clearly not one of ordinary hypnosis, though obviously abnormal; it is not sufficiently suggestible. Yet, in this experiment, it is close enough to merge spontaneously into hypnosis. (6) The associative relation of Hyp. 2 with remote hypnotic experiences is a confirmation of a relation already known. (7) Certain felt differences between Int. and hypnosis are described by O while in hypnosis. The former is felt as a state of neither sleeping nor waking, one of not knowing much, nor thinking of anything, nor being able to think of many things—a state of nightmare-like discomfort because of its felt complications: a state of stupidity. Hypnosis is not felt as sleep nor yet as waking—a state of greater comfort and knowledge; of mental clearness; of unconcern about things not felt as intended for the hypnotized; of indifference to everything not felt as planned for him by E; yet the hypnosis that developed spontaneously in the midst of Int. did not seem in retrospect, to O, different from Int. About this, however, he speaks with less confidence. (8) O regards himself as truthful but stupid in Int. (9) The immediate cause of suggested paralysis is felt by O to be forgetting how to make the forbidden movement—an inhibition of associations. This mode of executing the suggestion seems to have been spontaneously selected. (10) O's memory in hypnosis seems sometimes a little sluggish. He has to be plied with questions in order to reveal his actual knowledge. Sometimes he seems monosyllabic; sometimes more talkative, opening unsuspected vistas of great interest. Had they been suspected, the neutral method of these experiments would have forbidden a direct inquiry of O. (11) The idea of what he may be doing in Int. is not sufficient to make O perceive that he actually is doing it. He cannot perceive certain acts merely by having his attention called to them.

EXPERIMENT 13.

June 10, 1921, 9:30 A.M.

O: G. E. H. E: C. T. B. R: J. L. B.

(Extensive records were made by E also, during the experiment. When not specially indicated O's replies were given orally.)

HYPNOTIC STAGE 1:

Directions to O: When you awaken you will take your seat at the automatic-writing table. After you sit down there, no words uttered by me will have any meaning for you, until I request that you let me feel of your left hand, after which my words will once more have meaning. Your right hand, meanwhile, will be able to understand my words and to act automatically in accordance with them. (Directions carefully repeated; and then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

O wakens and takes his place at the table.

E: Do you hear me? O: (Silent, writes) *No, but I can hear. I won't hear.*

E: Who are you? O: (Silent, writes) *G..... H.....* (the two names in full).

E: What are you doing? O: (Silent, writes) *Answering you.*

E: Do you know that you are writing? O: (Silent, writes) *No, but I am.*

E: What is the rest of you doing? O: (Silent, writes) *Nothing.*

E: If you understand me write 6, if not write cow. O: (Silent, writes) *6 I can understand | but I think I can't . . . | . . . think I can't*

At this point R begins to take part in the questioning, being largely prompted by E. The writing that accompanied it is inserted below, as there is no record, only internal evidence, to show the points at which it occurred.

R: Are you awake? O: Yes.

R: How long? O: Five minutes.

R: Do you know what you had for breakfast? O: Yes.

R: What? O: (Laughing) Scrambled eggs.

E: Do you hear me speak? O: (Silent.)

E: Do you hear me write? O: (Silent.)

R: Who else is here? (The answer if given is missing from the record, but O's next reply indicates that he answered this question correctly.)

R: Has he said anything to you? O: Asked if I were awake. (This probably refers to some question put to O on coming out of Hyp. 1—a not uncommon question.)

R: What did you say? O: That I was.

R: Did he say anything else? O: No.

E: Won't you look at me? O: (Takes no notice.)

R: Can you see Dr. B.....? O: Yes.

R: Have you looked at him? O: Yes.

E: Why don't you reply to my questions? O: (Silent.)

R: Why don't you reply to Dr. B.....'s questions? O: He hasn't asked me any.

R: What is he doing? O: Writing.

R: What? O: Don't know.

R: Have you any idea what it is? O: No.

R: Would you like to know? O: (Slightly laughing) Yes.

R: Why? O: No reason in particular.

Here E walked in front of O, touched him, and leaned forward to look pretty closely into his eyes, but was ignored.

R: What are you thinking about? O: Nothing.

E: Can you feel my touch (slapping O's left hand)? O: (Silent.)

R: Can you feel Dr. B.....'s touch? O: Yes.

(At this point something is apparently missing from the record.)

R: Why hesitate in saying no? O: No what?

R: To last question? O: Don't know what it was.

E: Why don't you reply to my questions? O: (Silent.)

E: Do you feel my touch (slapping O's knee)? O: (Silent.)

Here is the writing produced during the foregoing conversation.

. . . | *No I think I can't because I | can't understand . . . because I can't | understand I won't hear | I can't understand so I can't hear | but I really can can really can and am | Yes but I can't answer*

The writing now ceases during the following test.

R: Tell me if you feel a touch. O: What touch?

R: Any touch.

E then touches various parts of O's body—legs, feet, left hand, right hand and right arm. O responds to all except those on the right hand and right arm, which is anaesthetic to the shoulder. (The record omits to state whether O's eyes were open or shut.) The writing begins once more with the following questions:

E: Why don't you look at me? O: (Silent, writes) *Can't understand so can't hear | but I can understand*

R: Why don't you look at Dr. B.....? O: Why should I?

R: Dr. B..... is going to pass in front of you and I want you to pay attention to him when he does.

E walks in front of O, kneels to look into his eyes, touches his leg. O appears not to look at E but beyond him.

R: Are you paying attention to him? O: Yes.

R: Are you looking at him? O: Yes (incorrect to all appearances).

Then E asks the question as arranged in Hyp. 1.

E: Let me feel of your left hand. O: (Responds immediately, with a pleasant change of expression and a bit of surprise in his manner.)

E: Do you feel my touch? O: (Eyes open) Yes.

A test for anaesthesia of the right hand here gives positive results only as far as the wrist.

E: Are you awake? O: Yes.

E: What have you been doing since sitting here? O: Talking with Joe.

E: What have I been doing? O: (Voice) I was looking at Joe all the time. (Hand writes, now and during the question following) *Writing and asking questions which I couldn't | understand so I couldn't answer | I can understand you now but I | can now*

From this point forward, in this experiment, all the writing was produced spontaneously, *i.e.*, without intended suggestion by E so far as the record shows.

E: Yes, but what was I doing? O: U.....h (as though about to speak, but in much hesitation.)

E: What have I been doing? O: (Voice) I hope this good weather will keep up for a while, that we have been having so long, don't you? (Hand) *I don't remember I | wont tell you those things because I | can't but of course I know*

E: (Evidently caught unawares) Yes—I'd like some rain myself. How did you happen to make that comment just then about the weather? O: Well, we've been having such good weather lately I hope it will keep up.

E: What have you been doing while sitting here? O: (Voice) Talking with Joe for a while. (Hand) *I have been . . . talking to Joe that's right | them | but . . . cause I wouldn't hear | you so I wouldn't | answer*

E: What else? O: (Silent.)

E: What else? O: That's all I've been doing—except thinking.

E: Thinking? What about? O: Thinking about the weather. Don't you think it would be nice to have it clear a while longer?

E: What has your left hand been doing? O: I don't remember.

E: Your right hand? O: I don't know.

E: Your left leg? O: I don't think it has been doing anything (laughs).

E: Do you suspect yourself of having done anything? O: Such as what?

E: Anything. O: I know I've been talking.

E: Do you suspect yourself of having done anything? O: No.

E: What are you doing while hesitating? O: Thinking.

E: Does this screen make you think of anything? O: I may have been writing.

E: Were you conscious of it? O: No.

E: Now I want you to think of some numbers. Think of counting it—1, 2, 3 for 3, etc.

E begins to impress various numbers on the anaesthetic hand by touching it with his finger the requisite number of times, at the rate of about three touches in two seconds, using the following series, determined by drawing numbers that had been shaken up together—9, 1, 7, 6, 8, 2, 5, 4, 3.

E: What number do you think of? O: I think of 9 (correct).

E: How does it appear in your mind? O: Well, I just thought of it.

E: Does it appear in the form of images? O: Yes.

E: Visually? O: Yes.

E: How? O: (Voice) Brightest in a long string of numbers. (Hand produces what may perhaps be taken as two 9's one under the other; and under both a legible "you"; then) *you have been touching my hand and it | makes | me think of those numbers but I don't know you are touching me . . . | . . .*

E: Do you see any of the other numbers? O: Yes, this one (9) being in red.

E: Once more, think of a number (two touches were given, one being intended, the other accidental and not in the customary manner).

O: (Voice) I thought of 11 (incorrect). (Hand) *Two touches. This 11.*

E: Think again, please. O: 7 (correct).

E: Again. O: 6 (correct).

E: Again. O: 8 (correct).

E: Again. O: 2 (correct).

E: Again. O: 5 (correct).

E: Why any of these? O: (Voice) I just see them. (Hand) *No I see them because I feel them though I don't know | I feel them I'm telling you as well as | I know but I don't know en* | (margin of sheet reached here) *enough to tell you right . . .*

E: As in the first case? O: Yes.

E: Any color? O: Red.

E: Think again. O: 4 (correct).

E: Think again. O: 3 (correct).

E: What have you just been doing? O: Thinking of numbers.

E: Anything else? O: No.

E: Are you awake or asleep now? O: Awake.

Tests for suggestibility here given were negative.

E: Do you feel as usual? O: Just about.

E: What is the difference? O: (Voice) I feel sleepy. (Hand) *It isn't sleepy its because I can't remember or think | of anything new it makes me so stupid | I think its being sleepy.*

E: Do you think you would be able to take an examination as you are now? O: I wouldn't want to.

E: Why? O: Too sleepy.

E: Can you recall everything that has happened while you have been sitting here? O: Yes, everything.

E: Does it stand out pretty clearly in memory? O: Yes.

E: What things stand out? O: Talking.

E: Is that all? (E repeats the question and O hesitates.) O: (Voice) Yes, you've been touching me and I 've been thinking of numbers. (Hand) *Of course I've been doing more but don't | like you to ask me because I don't | know and I don't like to seem so | stupid, but I think I know every- | thing but I don't. I can't rememb* (runs off paper here) *| what I do know even very well | I can't even remember don't want to cant.* | . . . | . . .

The foregoing writing was in process of production from the time the pertinent question was asked to the end of the next few questions.

E: What day of the week is this? O: Friday (correct).

E: What time of day? O: I don't know.

E: Morning or afternoon? O: Morning (correct).

E: Can you give the time approximately? O: No, well, half past nine (in reality an hour later. O gives the hour at which the experiment started).

At this point, tests for anaesthesia of the writing hand were made, with positive results as far as wrist. The writing thereupon ceased. To O, whose eyes were still closed, E suggested various movements for right and left hands respectively. The left hand declined, the right (concealed) hand accepted, these suggestions, though O thought both hands were equally under his control. In a single exception the right hand did not obey when O, however, thought it had.

E: Why didn't you answer my various questions while sitting here? O: I did.

E: Was there no group of questions which you didn't answer? O: No (with a look of slight surprise at these two questions).

E: How do you feel? O: A little bit sleepy.

Hypnotic Stage 2:

E: What were you doing at the writing table? O: I was writing.

E: What were you writing? O: I was writing answers to things you asked me.

E: For example? O: You asked me if I could hear you.

E: Could you? O: Yes.

E: What did you say when I asked you that? O: I didn't say; I wrote.

E: Why didn't you say? O: Because you told me to write.

E: Could you really hear me? O: Yes, I heard you.

E: Did you tell B..... (R) that you heard me? O: I was writing all the time.

E: Did you tell him that you heard me? O: Perhaps I said I didn't (correct), but that didn't count. I was writing you the answer.

E: Why didn't it count? O: Because *I* was answering you by writing you the answer. (Much emphasis on the I.)

E: Who was talking if *you* were writing? O: (Silent).

E: Why don't you answer the question? O: *I* was answering you by writing (again the emphasis).

E: Then who was answering B..... by talking? O: Well, it was my voice, but I was answering you by writing.

E: Who controlled your voice? O: I don't know.

E: What else was going on at the table? O: You were touching me.

E: What sort of touches? O: With your finger, your foot, and something sharp (the latter reserved here, as always, for the anaesthetic area).

E: Where did you feel the sharp touches? O: On my right hand.

E: Why didn't you tell me so at the time? O: I thought I couldn't feel it, but I could.

E: What other things did I do? O: You were writing and kept touching my hand.

E: What else? O: You walked around.

E: Did you notice me doing it? O: Yes.

E: Why didn't you respond to me? O: I did.

E: Why didn't you look at me? O: I *did* see you.

E: Did you look at me? O: No, I couldn't.

E: Why not? O: I don't know.

E: Think hard. O: It wouldn't let me.

E: (Not quite catching answer) "It" wouldn't? O: It wouldn't let me—something wouldn't—*I* wouldn't.

E: Why do you change from "it" to "something" and then to "I"? O: *I* couldn't look at you because——

E: Because what? (O shows signs of uneasiness, tension in the face muscles, while the same question is given three times.) Because I just couldn't look at you, that's all.

E: Do you recall any other things you said at the table? O: That I *said?*

E: Yes. O: I said different numbers (correct).

E: Why did you say those numbers? O: Because I made them be said.

E: What do you mean? O: You were touching my hand and I *made* those numbers; I made them be said.

E: How did you happen to select those numbers? O: I didn't *select* them, you touched them on my hand.

E: What if I did touch your hand? O: I wanted to let you know that I knew you were touching me.

E: Did you know at the time you wanted to let me know? O: (With emphasis) *I* knew.

E: Was there anything that you didn't know? O: Yes.

E: What? (O again shows signs of uneasiness and effort. E repeats the question.) O: I don't know what.

E: You can give no further information about that? O: (After effort) I couldn't say the things I wanted to, nor see what I wanted to, nor do what I wanted to, nor hear what I wanted to. Of course, I really could

do all those things, but I didn't think so—and I knew it, but *they* wouldn't let me.

E: Who were "they"? O: (Half mumbling) I don't know who *they* were. (Then, clearly) It wasn't *they;* it was *me,* but it *wasn't me*——

E: If it wasn't "me" who was it? (Correcting himself) No, you say it was "me" and wasn't "me." How can that be? O: Well, it wasn't *me,* but had something to do with me—I don't know what.

E: Who is really talking to me now? O: I am.

E: The same "I" that knew all about these things at the table? O: Yes, of course.

E: While you were at the table, was your "I" answering B.....? O: No, *I* wasn't.

E: Was it answering me? O: Yes.

E: With your voice? O: No, by writing.

E: What was using the voice? (O shows some effort or uneasiness. E repeats the question.) O: I don't know.

E: Were the answers given at the table honest answers? O: (Promptly) Yes.

E: The answers given by your voice? O: I guess they were *honest.*

E: Why do you speak so guardedly? O: They weren't true and may *not* have been honest; but I suppose they were.

E: Were you in doubt of them at the time? O: *I* (Emphasized) knew they weren't so.

E: Why didn't you give me the true answers? O: Because I couldn't say them. I wrote you the true answers mostly.

E: Does that experience seem to you just like telling a lie ordinarily? O: (Earnestly) Oh no. *I* was telling the truth all the time.

E: Even when you answered with your voice? O: *It* didn't know any better.

E: Why do you say "it"? O: Because I couldn't use it (meaning, apparently, the voice), I was shut up and could only get out through my hand.

E: Are you answering my questions on the basis of direct memory? O: Yes.

E: Are you consciously affected by any theories of Psychology? O: (In some surprise) Am I what?

E: (Repeats.) O: I don't *believe* so.

E: Are you trying to report what you seem to have observed directly in yourself? O: Yes.

E: Has it been hard to give the answers? O: (Quickly) Yes.

E: Why? O: (Pausing) Because I can't explain them myself.

E: What do you mean by "explain"? O: When you ask me *why* of all these different things, I don't know why.

E: Have you any doubt about the correctness of your report about the facts? O: (Quickly) No. I don't know that I have said *clearly* what I mean.

E: Can you compare your experience at the writing table with any experience you have had in ordinary life? O: (Quickly) No.

E: (After a pause) What are you thinking about now? O: Nothing.

E: Would you like to wake up now? O: (Promptly) I don't care.

E: What have you just recently been hearing? O: Your writing—mandolin playing (both correct).

E: When you were writing automatically, did you make anything beside letters and words?? O: I tried to make some letters sometimes that I couldn't.

E: Do you know what you made in place of those letters? O: No (doubtfully). Just a scrawl, I guess.

E: What started you to write from time to time, while sitting at the table? O: When you asked me questions that weren't being answered right.

E: What was that noise, George (a horse galloping past)? O: A thumping.

E: What may have produced it? O: I don't know.

E: Are you asleep or awake or neither? O: Nearly asleep.

E: Do you seem to yourself to be dreamy? O: No.

E: Will the "I" present when you wake up be the same as that engaged in writing? O: I hope so.

E: Shall you be able to tell? O: I don't know.

E: Will the "I" present when you wake up be the same as that controlling your voice at the table? O: I hope not.

E: Were you uncomfortable at the table? O: I don't know what you mean.

E: Did you *feel* uncomfortable there? O: (Silent, shows signs of uneasiness.)

E: (Repeats question.) O: I don't remember.

E: Do you remember any uncomfortable experiences since you went to sleep? O: Yes.

E: What? O: I couldn't see what I wanted to; nor say what I wanted to; nor sometimes write what I wanted to—then I could only make a scrawl.

Thinking O had said something about hearing, missed in the process of note-taking, E asked the next question.

E: What did you say about hearing? (In the answer to this question there appears a possibly important difference between the records made by R and E respectively—important because one of these in form contradicts a statement by O made earlier in this stage.) O: (According to R) I could hear all I wanted to. I could hear better than the others. (According to E) I could always hear everything. (Then, after a pause) I could hear better than the others. (This second sentence, alike in both records, probably means, "better than I could use the other senses.")

E: What prevented your writing what you wanted to? O: The same "they" that wouldn't let me see what I wanted to wouldn't let me write what I wanted to.

E: About what time is it, do you think? O: I don't know.

E: Guess. O. About noon (correct).

E: Why do you say that? O: You asked me to guess.

E: By what do you judge? (After a pause) Because I hear different sounds—whistles and things that blow around noon. (Such a whistle had sounded in the distance.)

E: Do you feel now just as you do ordinarily? O: No.

E: What is the difference? O: I'm not awake now.

E: Do you feel all right? O: Yes.

E: Would you like to remember all that you have been experiencing? O: Don't know.

POST-HYPNOTIC STAGE 1:

E: Do you know what time it is? O: About 10 o'clock. (O had been hypnotized about 9:30. It was now about 12:00.)

E: Why do you say that? O: (Smiling) I don't know; it seems about that time.

E: How do you feel? O: All right.

E: Awake? O: Waking up (laughs, then after a pause, spontaneously) I feel as though I had been very deeply asleep—miles away.

E: Do you remember anything that has occurred this morning since you have been asleep? O: No.

E: Try. O: (After a pause) I can't (with a smile).

E: Does that table (pointing to the writing table) remind you of anything? O: Yes, experiments carried on there.

E: Anything occurring this morning, I mean? O: No.

Hypnotic Stage 3:

E: What were you doing at the writing table? O: I was writing answers to your questions.

E: What were some of those answers? O: I was writing that I could hear you but couldn't answer you.

E: What else? O: I could see you but couldn't look at you. (If this refers to a written answer, as the form of E's question implies, it is incorrect; if merely to events of the preceding stage, as O's answer to the next question implies, it seems to be correct, according to the circumstantial evidence.)

E: Anything else? O: You asked me why I didn't answer you.

O was then wakened, after being given the suggestion that he would recall everything when awake.

Post-hypnotic Stage 2:

E: Are you awake? O: Yes.

E: Do you remember anything? O: Yes, but it all seems like a dream, not like anything real.

E: What do you recall? O: I was thinking about sitting at the table writing. (Then, in astonishment) It doesn't seem real or possible!

E: What do you recall? O: (Pausing briefly) Why, I was recalling the situation there. What a funny one it was! If (smiling) I am remembering it rightly. It seems weird.

E: What was it? O: I seemed to be divided in two. I remember thinking of one thing and at the same time thinking of another—trying (R's record gives "wanting") to do something and not letting myself do it. Terrible mix-up!

E: Which of these are you now? O: Both, I guess (laughing), if I remember. I don't remember much about it. Seems more like a nightmare than any real thing.

E: Does it disturb you to recall it? O: It's not pleasant to recall by any means. If not interested I wouldn't. (R notes here in a parenthesis that it "had been suggested that he would be interested." There is no other record of such a suggestion in that form.)

E: Interested in what sense? O: To find out about it; it's such an interesting condition.

E: Do you remember anything else? O: Vague generalities—nothing much in detail—like a dream. Chief thing that stands out is doing two things at once. Horrible to think about!

E: Why horrible? O: Because you don't feel that you were yourself. Terribly confused state of affairs. (This in a pleasant tone of voice.)

E: When you have previously recalled things by my help, have they faded away? O: Yes. I remember them only as they were reported to you (*i.e.*, as given in a post-hypnotic state).

E: Do you later remember that they felt horrible; or do they continue to feel horrible? O: Usually one thinks of oneself as having judgment and fitting things together; and I don't seem to have been present in that sense though present somehow in both the experiences of that time; but it seems wholly alien to me.

E: (Repeats the question.) O: They continue to feel horrible.

E: Are you unhappy to recall it? O: Yes, it isn't pleasant though it is interesting.

Probative character of this experiment: O was able to gather information, and act upon it, in the way of making discriminating replies, at the same time that he was, in some sense, unaware of it all, and otherwise occupied. Afterward, however, he was able to recall it, though meanwhile receiving no information about it from any source outside himself.

Associative relation among the several stages and subgroups: Hyp. 1 seems not to be recalled in Int. by either partial group, though experiences in this stage are determined in great part by the former. Hyp. 1 is, however, recalled in Hyp. 2; but there is no reference to it in any later stage. Of the component groups in Int. the hand-group is dissociated from the voice-group, though stimuli belonging to the former produce distorted effects in the latter. At least a part of the voice-group was included in the hand-group. These groups are partly united in Hyp. 2, disappear in Post-hyp. 1, reappear in Hyp. 3, and by suggestion in Post-hyp. 2, but incomplete in details and rather vague, yet in some respects more fully than in Hyp. 2, *e.g.*, in recalling discomfort and its character.

Comments: (1) The interference between the partial groups of Int. is to some extent mutual. The voice-group can't see (look), remember, hear, get touch perceptions, adequately. The hand-group feels itself limited, for expression, to the hand, and even there feels hampered. (2) There is an apparent contradiction in O's references, during Hyp. 2, to his auditory function in Int. ("I couldn't . . . hear what I wanted." "I could always hear everything" or "could hear all I wanted to"). This contradictory appearance is removed, if we regard these utterances as

referring to different component groups of Int. Such an assumption is justified by the following facts: O makes such a distinction elsewhere in language which he insists on, in spite of its apparent contradiction. When he said, " I could hear all I wanted to," he added a reference to the superiority of hearing to the other sensory functions. This utterance seems best explicable by reference to the emphasis laid on hearing in the original suggestion (for he has no apparent auditory defect in the normal state); and, by implication, thus, to belong to the hand-group. (3) The suggestion that E's words would have no meaning, though it really left room apparently for response to crude hearing of E, developed in O a systematized auditory anaesthesia for E, accompanied, spontaneously, by a systematized motor defect—the inability to look at E. O's assertion that he *was* looking at E, being to all appearances false, however much it needs explanation, cannot be regarded as having any weight against this conclusion. Though anaesthesia toward E was limited, he was not wholly ignored. His touches on certain parts of O's body were recognized as by him. O asserted in Hyp. 2 that he could " see " E but could not " look " at him. (4) The events of deep hypnosis can, by suggestion, be made to persist more or less definitely after waking; but in the case of this observer they quickly fade and only persist thereafter indirectly, as memories of what he once said that he recalled. (5) Some of O's replies lead one to ask whether he was in distress during this experiment. The external signs of distress were no greater than the foregoing record shows. O's own language must be interpreted in that light. The distress, such as it was, is apparently that of felt confusion of ideas. (6) The writing hand is evidently guided by stimuli received as it moves. (7) Dissociation is indicated in the delusion of motor control over the writing hand. (8) The speech of O in Hyp. 2 and the automatic writing show the felt confusion reigning within, by the difficulties with pronouns. " I " is used indifferently in both speech and writing for the voice-group and the hand-group. " Me " is used likewise in speech. O seems, however, at times to prefer to identify " I " with the hand-group, which, to him, seems less " stupid " for the apparent reason that

it knows more of what happened and can recall more. Observer J. L. B. preferred the voice-group. A tendency to reject something from the scope of the " I " is indicated by placing elsewhere the inhibitory power, whose effects he has felt. He calls this variously " it," " something," " they," and, almost in the same breath, " I," indicating a felt unity even in the dissociation. It seems possible that this line of distinction be drawn between the hand-group and the voice-group. (9) The restoration of meaning to E's spoken words, by means of the procedure indicated to O in Hyp. 1, did not bring to an end Int. The writing continued. (10) The hand-group included, at its time of greatest extent, touch and kinesthetic sensations from the right hand and right arm, auditory percepts of E, and a range of items, identical with or referring to a large part, at least, of the voice-group. (11) External signs of effort, tension, appeared in four recorded instances, of which three, and possibly four, were concerned with attempts to answer questions about the voice-group of Int. (couldn't look; didn't know what it was he didn't know; didn't know who was using his voice; couldn't recall whether or not he felt uncomfortable at the table. These are all concerned with present or past inhibitions). (12) Time orientation is disturbed in the latter part of Int. and in the beginning of Post-hyp. 2; it appears to be normal in Hyp. 2.

PART III

CONFIRMATORY EXPERIMENTS

Section 1. Experiments I–V

(This group of five experiments is defective in minor ways, according to our canon, but yet seems to be strictly probative.)

EXPERIMENT I.

Jan. 18, 1920, 4 P.M.

O: G. E. H. E: C. T. B.

(In this experiment the records were made by E, who was the only person present besides O.)

Hypnotic Stage 1:

When O had been hypnotized, he was told that, on awaking, he would be given a sheet of paper on which two numbers would appear that were to be added, and that, on being rehypnotized he was to give the answer at once.

With regard to automatic writing, the record shows no indication as to whether any suggestion was given. This omission was discovered when the record was being later examined for interpretation, and this omission noted thereon—a further note being added to the effect that, according to the "clear memory" of E no such suggestion had been given.

Interim Stage:

On waking, O changed his seat to one by a table. He was given a sheet of paper and told to write the first stanza of "America." This he did. On the upper left and lower right corners of this sheet were the numbers 78 and 47 respectively. A screen was then so placed as to conceal his right hand and forearm, a pencil was put into that hand, and a sheet of paper placed conveniently. O was now engaged by E in conversation, during which O was asked after a time whether he was doing anything with his pencil. Nothing but making crosses and meaningless marks, was the reply. Meanwhile the right hand was making the following record in a sprawling, interrupted fashion: *78, 47, 78 Page* (all the foregoing written in a kind of conglomerate mass) | *tells wh n* (which number) | *sum of wh* | *numbers which* | *are o* (one or on?) | *would be on* | *the paper and then* | *tell you what they* | *were when you asked* | *the*

At length O was asked to return to the arm chair to be rehypnotized.

Hypnotic Stage 2:

O gave the correct answer 125 at once, orally.

E: Where did you get the numbers? O: (After an obvious effort) That's the funny part. I don't know *where* they were. I don't think you told me.

E: How did you get the number (*i.e.*, the sum)? O: First thing that came into my head. I don't think I saw it.

POST-HYPNOTIC STAGE:

O stated in reply to general questions that he remembered nothing of either trance state nor what numbers were used, nor how he got them; but he recalled well the conversation of Int.

Then occurred the following attempt to remove the inhibition:

E: Do you recognize the number 78? O: (After a brief pause) Yes, I think that must be one of them. Sounded familiar (correct).

E: Do you recognize 125 (the sum)? O: (After a brief pause) No, I don't believe that was one.

E: Do you recognize 47? O: I think it was forty-something. It might be 46 (partly incorrect).

E: (Looking steadily at O) Look at me. Now you may think hard and recall everything in the experience. O: (After pause and apparent effort) No, I can't recall.

Placing hand on O's forehead, E, with a confident manner, tells him to think hard and try to recall. Then, after a pause and apparent effort to recall, O writes: "They were on a paper, on the corners" (correct). O substituted writing for speaking at E's request, as a new observer was coming into the room when O was about to make reply.

Probative character of this experiment: In Int. two dissociated groups of mental items are indicated; "two," because they are different in content, and lead to different expressions in voice and hand, respectively; "dissociated," because one at least—the voice-group—does not know the meaning of what the other is doing; "mental," both of them, because, according to the standard admitted in the ordinary affairs of life, the only one in doubt, viz., the hand-group, implies recall of experiences of Hyp. 1, viz., the type of task suggested, and of the special numbers, just previously seen, by which the task was to be executed.

There is no objective evidence that the perception of the numbers was co-conscious, nor could O recall the hand-group in any later stage. The Memory Test thus fails.

Associative relations among the several stages and subgroups: The voice-group contains items about right-hand movements but not their correct meaning, substituting "dots and dashes" for what was really significant script. Hyp. 1 seems to be quite dissociated from this group but not from the hand-group, which is so peculiarly affected by the memory from Stage 1 to the effect that the answer to the problem is to be given in Hyp. 2, that this hand-group cannot quite succeed, even in automatic writing, to reveal

the answer in advance. The hand possibly starts to write it but stops short. ("sum of wh | numbers which | are o"). In Hyp. 2 there is a curiously complete suppression of Hyp. 1. The task set in the latter is executed, but that it is a task and has been completed is not known. The suppression of Int. seems almost complete; that there were number data seems to be known, but their source is not known. It was impossible to discover in this experiment whether the actual solution of the problem was performed by the hand-group or in a very brief hypothetical transition stage, developing at the beginning of the second hypnosis and disappearing with the attainment of the answer. By O in Hyp. 2 the number, *i.e.*, the sum, was felt as appearing without indication of origin. These two hypnotic stages were thus in some way different in status, not coextensive.

In Post-hyp. there is partial association with the hand-group of Int. I say "partial" because of the evidence above that items were present in the earlier which were absent in the later. There is no manifest lack in the association of the voice-group with the later stage. Conversation was recalled. But the suppression of both hypnotic stages seems to be complete.

It is not to be supposed that the full range of association- and inhibition-relations among the foregoing stages and subgroups is included in the facts just cited. Other tests, omitted in this experiment but fortunately included in others, would be required for complete determination. We cannot tell whether the number perception of Int. belonged to both partial groups or only to the hand-group, though a straw pointing to the latter exists in this fact, that in Post-hyp. the conversation of the voice-group was promptly recalled, whereas the source of the numbers was recalled only after considerable insistence by E. This seems to indicate that the two bits of experience did not have quite the same status in Int.

EXPERIMENT II.

April 20, 1920, 3:45 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

(This experiment immediately followed one that was a complete failure because O remembered in the Interim Stage the events of Hypnotic Stage 1.)

HYPNOTIC STAGE 1:

Directions to O: You will multiply two numbers. The first is 59; the second is the number of white boxes on the shelf opposite you. When rehypnotized, you will give the answer at once, raising your hand the moment you begin thinking of the problem. (An amnesia suggestion was also given. The number of boxes was 6. These were the usual pamphlet boxes of a library. The record does not show whether they were a specially arranged group, or the set that usually stood among many closely packed folders also opposite O. His later reference to folders indicates the latter. If so, E cannot, of course, say that O did not already know the number of these. There was nothing, however, in the usual course of events in the room, to call his attention to them, so far as E knows.)

INTERIM STAGE:

E: Tell me what has happened. O: I can't.

E: Try. O: (After long pause) It seems as though I knew, but I can't remember anything in particular—much like trying to remember a dream; only I usually remember something of a dream; in this case, less.

E: Have you been doing anything, since you woke up, that has any connection with anything that happened in your sleep? O: No. I can think of things that *might* have something to do with it; but don't think they would with what you'd ask me.

E: What were these things? O: What I was going to do after I left here; and other casual things—the folders on the shelves opposite, books, etc., because I always think of what I'm looking at.

HYPNOTIC STAGE 2:

O raised his hand and after about 2 seconds said 354 (correct).

E: What is that? O: The answer to the problem.

E: When did you do it? O: When talking to you. I didn't know I was doing it then.

E: Why did you raise your hand? O: Because you told me to.

E: When? O: When I began to think of the problem.

E: Did you know the answer when you raised your hand? O: I think I did.

E: Why did you wait so long before giving it? O: I didn't think of it right away.

E: But you did when you raised your hand (not necessarily, of course, according to the strict letter of the instructions). O: I don't remember when I raised it (though he seemed to remember that shortly before).

E: Did you try to recall, before you were rehypnotized, what happened in the previous hypnosis? O: Yes. I knew it, but could not recall it.

E: Were you answering honestly? O: Yes. I didn't know it then; but I do know now that I did then. I wasn't conscious of it then.

E: When did you notice the boxes? (It would have added confirmatory detail had E tried first to evoke the knowledge—if it existed—that boxes were in question.) O: As soon as I opened my eyes.

E: Did you know what you wanted of those boxes? O: Not then, but now I do.

E: Why did you forget your experience? O: Because you told me I'd forget.

E: Are you asleep? O: No.

E: Are you awake? O: No.

E: What, then? O: Hypnosis.
E: What does it feel like? O: Mostly like sleeping.

POST-HYPNOTIC STAGE:
E: Do you remember what took place? O: No.

Probative character of this experiment: Having forgotten the plan provided by E, O gathers data according to that plan, while in some way unaware of so doing, afterwards recalling both, without access to any information outside himself; asserting (unverified) that he had at the same time been performing co-consciously a multiplication, in further execution of the plan; asserting, also, co-consciousness about the plan, viz., that he both knew it and did not know it.

The objective evidence shows that the multiplication was indeed performed; but not beyond a doubt that it was all done in the Interim Stage.

It is only the taint of suspicion attaching to the source of the data that prevents it being included in the probative group of Part II.

Associative relations among the several stages and subgroups: Hyp. 1 is very vaguely associated with ("known" to) the dominant group of Int. and fully with the subdominant group. It is also associated with Hyp. 2, but not with Post-hyp. The subdominant group of Int. is dissociated from the dominant group and reunited with it in Hyp. 2, while both are dissociated from Post-hyp. Hyp. 2 is also dissociated from the latter.

EXPERIMENT III.

April 28, 1920, 2 P.M.

P: G. E. H. E: C. T. B. R: H. W. L.

HYPNOTIC STAGE 1:
E gave the following directions to O: When you awake you will be given a chance to write automatically. You will be shown a paper containing several digits. For each digit you will make the corresponding number of marks—circles for black-ink digits, crosses for red-ink digits, arranging them, for each digit, in a row beneath the marks for the preceeding digit, and you will not be aware of what you are doing. (This was said carefully twice; and then) Do you understand? (Affirmative reply.)

INTERIM STAGE:
O does not recall what happened in the preceding stage; cannot tell; cannot get it at all. He then takes his place at the writing table.

E: Do you know what you are going to write? O: No.

E: Do you expect me to tell? O: Yes, or else I wouldn't know what to write.

Test shows that writing hand is not now anaesthetic.

E: What did you say you were going to write? O: You haven't told me.

Paper is now shown to O, containing 397, the 9 in black ink, the other digits in red.

E: Does it mean anything to you? O: No.

E: Did you do anything with it? O: No, it meant nothing to me.

E: How do you pronounce it? O: 397.

O has, however, been making crosses and circles that carry out correctly the suggestion given in Hyp. 1. Test shows that no touches on the writing hand are referred to it. (Record leaves it in doubt whether these were referred to the arm on that side.)

O is now shown the number 246, the 4 in red ink, the other digits in black.

E: What does that mean? O: 246. It doesn't mean or recall anything.

As before, the writing hand has been executing correctly the original suggestion. Test shows that the hand is anaesthetic.

E: What did red ink mean? O: I don't know any more than what black ink did.

E: Think you can't tell us what it meant? O: No.

E: It recalls nothing? O: Not a thing.

E now observes that the hand is writing.

E: What are you doing with your hand? O: Not doing anything with it.

E: Now what did black ink mean? O: I don't know what it meant. Didn't mean anything.

E: Can you name all the men in your fraternity? (O gives an extended list.)

Tests again show anaesthesia of the writing hand, which has been producing the following script:

I was to make crosses | when there was red ink and | circles with the black | and the numbers of | digits I was to make the | numbers equal to them | on the paper. (New sheet.) *Black ink meant to make | circles equal to the number of | digits*

Here are the correct replies to the questions which O has, at the same time, been declaring his inability to answer, and they are not written in response to any suggestion that E is aware of having given.

The screen being now removed and the writing hand touched in O's sight, he responded to every touch, declaring that this touching of the hand seemed like a new experience.

E: Have you anything more to say about your experience in this experiment? O: No.

E: Have you told all about your inner experiences? O: Yes, practically all.

E: Can you squeeze out anything else that I might be interested in knowing? O: No, not a thing that is at all important.

E: Have I just asked you your name? O: No.

E: Sure? O: Yes, absolutely.

Being pressed to report all he can that is pertinent, O continues.

O: I remember a feeling of a length of time, of events happening without meaning—in the chair before coming to the table.

E: What events without meaning? O: Those in hypnosis—a sense of things happening, but I don't know what they were.

E: Is it ever a bare blank? O: Yes, but not this time.
E: Are you awake? O: Yes.
E: Are you sure you are not now in hypnosis? O: Yes.
Tests for suggestibility fail.

HYPNOTIC STAGE 2:

E: What do you remember? O: I knew what it was all the time; but I didn't know it myself. I knew it, but couldn't think of it—couldn't think of it at all; but I really knew it all the time.

E: You were playing a game on us, weren't you? Deceiving us? O: No, for I didn't know.

E: You mean that you didn't, and yet did, know? O: No, I really didn't know it then—couldn't think of it, but really knew it. Like knowing a name and not being able to think of it; but more so, for in remembering a name you know that there is a name, but I didn't know that there was anything to remember.

E: Shall you be able to remember when you wake up? O: No, for I never do.

E: Can we believe these statements of yours? O: Yes.

E: What would you say if L..... (a visitor at this experiment) doubted everything? Could you say anything in answer? O: No, for there's nothing else to say.

E: Would you like help in recalling these experiences when you wake up? O: I don't care.

He was then told to waken when L..... should rap. Not accepting this suggestion, O was told to waken when E should count three (a very common mode of wakening in these experiments). Accepted: O thereupon is fully awake.

POST-HYPNOTIC STAGE:

E: Can you remember anything that took place? O: No. I feel as though I had been through a nightmare—feel confused, a disagreeable experience.

E: Why nightmare? O: It felt like trying to run and not being able.

Probative character of this experiment: The evidence consists in the production of written signs according to complex directions, which involved getting new information from the environment, also correct answering of questions, all of which was apparently unknown to another mental group, simultaneously present and intelligently active. At a later time O professes to know *both* of these preceding groups of experience, though, meanwhile, having access to no information outside himself. Unfortunately the records show no experimental check on the correctness of his feeling that he knew; the Memory Test was not fully applied.

Associative relations among the several stages and subgroups: In Int. the hand-group has associations with Hyp. 1, while at first the voice-group seems quite without such, though later very vague

memories recur. As between the two subgroups the hand-group is dissociated from (not "known" to) the voice-group, so far as we know the items in that group, except that vision and hearing seem shared between them, at least to an extent. There were no tests as to whether the voice-group is, in turn, dissociated from (not "known" to) the hand-group. Hyp. 2 reunited both groups of Int.—according to O's assertion, which, however, was not further tested. No tests were made for direct connection between the two hypnotic stages. Post-hyp. shows vague associations from earlier stages. The present evidence does not permit us to decide as between Int. and Hyp. 2. The only reported memory is that of a felt inhibition. There is apparently no association with Hyp. 1, but O was not pressed particularly on this point.

EXPERIMENT IV.

April 30, 1920, 2:30 P.M.

O: H. W. L. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: When you waken you will be given a chance to write automatically. You will be shown a piece of paper with digits on it. For each digit you will make the corresponding number of marks—dashes for those in black ink, triangles for those in red, arranging them in rows under each other. You will not be aware of what you are doing, nor will you remember this suggestion. (These directions were repeated; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

O is able to recall many details of events in the preceding hypnosis—events concerned with testing the depth of hypnosis; but he does not mention the foregoing directions. Being seated at the table, the right hand behind a screen and holding a pencil, he states in reply to a question, that this situation does not remind him of anything occurring this afternoon. (This was the first experiment of the day.) He is now shown a paper containing the number 4296, the outside digits in black, the inner in red.

E: What does this remind you of? O: Nothing except George's experiment yesterday afternoon (describing it). (The two experiments were alike in form, but differed in content—*i.e.*, in the digits selected and in the marks to be made by O. Hence, knowledge of the earlier could not insure a correct performance of the present one.)

E: Does it make you think of anything else? O: No. The numbers don't stand for anything to me, either.

Meanwhile his hand has made 4 dashes, in horizontal series; and, similarly, below this, 2 triangles, 7 dashes, and 6 triangles, each series under the preceding. (The first two are correct; the third should have been 9 and in triangles; the fourth should have been in dashes.)

To O is now shown a paper containing the number 6724, the digits alternately red and black.

E: What are you doing with your hand? O: Moving it around.

E: What are you making? O: Nothing—just moving it around.

Tests for anaesthesia were negative.

Meanwhile O's hand has made the following five groups of triangles and dashes:

(1) 7 triangles, 7 dashes, 2 triangles, 4 dashes (all correct except the first).

(2) (Correct group.)

(3) (Correct group.)

(4) (Correct group.)

(5) (Group showing confusion and not easily decipherable.)

This perseverance in fulfilling the suggestion by repetition of the execution, matches the instances of word- and phrase-repetition in automatic writing. Such multiplying of instances was not contemplated in the original suggestion.

O is next shown the marks he had been making.

E: Do these recall anything to you? O: No, except what George was doing yesterday.

E: Do they mean anything to you? O: I imagine that the triangles mean one thing, the dashes another.

E: Do they remind you of anything in your own experience? O: No.

Hypnotic Stage 2:

E: What were you doing when sitting at the table? O: Writing.

E: What? O: (Repeats the directions given in Hyp. 1.)

E: Did you do this? O: Yes.

E: Did I show you the paper on which you made these marks? O: Yes.

E: What did you say? O: I imagine it was like George's experiment yesterday (substantially correct).

E: When I asked if it recalled any part of your own experience, what did you say? O: I said no.

E: Was that the truth? O: Yes.

E: Were you aware of what the hand was doing? O: I know it was moving.

E: Did you know what it was making? O: No.

E: How could that be? O: You told me I wouldn't remember.

E: You say you remember now what you were doing then? O: (No answer.)

E: Did you know you were writing those symbols? O: I knew the hand was moving.

E: Do you think you did it correctly? O: Yes.

E: Did you have any doubt while doing it? O: I don't remember doing it.

E: What makes you think you did do it? O: You showed me the paper.

E: How do (did?) you know what the marks meant? O: You told me before what I was to do.

E: Think hard to see whether you can recall doing it? O: Can't seem to think.

(There was no Post-hypnotic Stage in this experiment as E proceeded at once to use Hyp. 2 as the first hypnotic stage of a new experiment.)

Probative character of this experiment: O executes, according to a plan received, a task that involves gathering new information. Of all this he is in some way unaware. He afterwards correctly states the plan but cannot remember executing it. Had he remembered, it would not be of real importance, since E had shown O in the Interim Stage what O had done. The memory test thus, in part, fails and, in part, cannot be applied, because of the events in the Interim Stage. The main part of the proof, however, is not hereby invalidated.

Associative relations among the several stages and subgroups: Hyp. 1 is associated in part with each group of Int., and is also associated with Hyp. 2. The hand-group is dissociated from (not "known" to) the voice-group to the extent at least of the *meaning* both of numbers read and of hand movements executed. For the reverse relation no evidence appears. The two groups are, apparently, not reunited in Hyp. 2.

Comments: (1) The errors in execution to be found in the automatic writing do not invalidate the probative character of that writing. They were too close to the plan to be acceptably viewed as having merely a physiological meaning. (2) A strong impulse behind the dissociation of hand-group from voice-group seems to be indicated in the fact that calling attention to the hand or the number is not sufficient—contrary to what is usual in normal states—to make clear and vivid the peculiar meaning of either.

EXPERIMENT V.

April 30, 1920, 4:15 P.M.

O: G. E. H. E: C. T. B. R: H. W. L.

HYPNOTIC STAGE 1:

An interruption which took E outside the room for a few minutes after the induction of hypnosis left O longer than usual asleep without special suggestions intervening. This should be borne in mind in connection with O's felt depth of sleep, as reported later. On returning to the room:

E: What has been going on? O: There has been talking. (E had been in conversation just outside the door.)

E: Is there any one else in the room? O: Yes (giving R's name).

Directions to O: I am going to give you a problem. You will add two numbers. The first is 682. When the second is given you will waken at once. You will remember nothing but will write the answer automatically. (Directions repeated: then) Do you understand? (Affirmative reply.) The second number is 947.

INTERIM STAGE:

O feels that he has been more deeply asleep than ever before; remembers nothing, and does not feel that there was anything to remember. He seats himself at the table, right hand behind screen, and begins writing at once, that hand becoming anaesthetic.

E: What are you doing? O: I heard my hand writing.

E: Close your eyes. (O does so; writing stops; anaesthesia remains.)

E: Look at your right hand? (O does so; feeling is at once restored.)

E then tries tests for suggestibility. O's reactions are slow: he says: "I don't want to do the things suggested." Finally, with eyes open, he becomes fully docile to motor suggestions; and when E, pointing at O, says firmly: "You will go to sleep," he falls at once into hypnosis and returns to the armchair.

Meanwhile O's hand had been writing 1629 (correct) about sixty times. The digits were usually clearly formed, and usually with a wider space between repetitions of the number than between the digits. 16229, 62, 1929, 16, 1626, 11629 each appeared once, involving, in these errors of doubling, omission, and substitution, each one of the four digits.

HYPNOTIC STAGE 2:

E: What were you doing in the writing chair? O: Writing 1629 (correct).

E: When did you solve it (the problem)? O: Before sitting down.

E: Was it all finished before sitting down? O: Yes.

E: Did you do it after you first woke up (*i.e.*, just after waking)? O: Yes.

E: What wakened you? O: The second number.

E: (Determined, evidently, to have no doubt left on this point) Did you do the problem before waking up? O: I don't think so.

E: What were you doing before sitting at the table? O: Talking—not solving the problem then.

E: Were you awake or asleep when I suggested that you couldn't raise your hand? O: Awake—I felt as usual.

E: Why didn't you do the things (referring to inhibitory suggestions)? O: I didn't want to.

E: Did you feel then as you do now? O: No. I had my eyes open.

E: Could you open your eyes now and stay asleep? O: Yes.

E: Were you then asleep even though your eyes were open? O: No, I don't think so—until I sat in this chair.

E: You will open your eyes but stay asleep. (O does so.) Do you see this letter in my hand? O: Yes.

E: What is it? O: S—the first letter in sixteen-forty-two (1642).

E: Why? O: Only thing it could be. (See introspection below.)

E: Have you anything more to tell about the problem? O: No.

E: When you waken you will remember what you have gone through.

POST-HYPNOTIC STAGE:

O is able to recall experiences of Hyp. 2. Then:

E: (Referring to the writing chair) Do you remember what went on there? O: Yes (but he finds that he can't recall).

E: Try again. O: Writing 1629.

E: Why? O: Because that was the answer to the problem given.

E: When did you remember? (This obscurely phrased question seems to have referred to recalling the task to be done.) O: Before I sat down at the table.

He recalls also what took place, says the record, "in last session," meaning, presumably, in the next preceding experiment upon him in hypnosis, a day or two before—April 28.

E: How do you feel when asked whether you are awake or asleep? O: I can't tell—I don't really think about it.

E: Do you feel differently now from the way you felt when at the table? O: Yes (adding, in reply, probably, to a series of prodding questions), I notice myself and feel excited; but I did not, at the table. I feel breathless after hypnosis, but not generally (*i.e.*, when hypnosis is not in question). I feel rather excited—an objectless excitement—the body excited but not the mind. I feel some discomfort.

He recalls the S in E's hand—the first letter of sixteen-forty-two. He had thought of 1629, which he had been writing, and 1642, a date, both beginning with S.

Probative character of this experiment: O is able to produce intelligible writing according to a plan known otherwise to E, while engaged in intercourse with E and apparently unaware of the meaning of his right-hand movements. "Apparently unaware" is the most that the evidence permits us to say; and this is inferred from the fact that, when asked "What are you doing?" O replies merely, "I heard my hand writing." He does not state specifically that he is aware of nothing else. The Dissociation Test was thus not quite properly applied. Later, however, he recalls correctly what he was doing, without, meanwhile, having access to any source of information outside himself.

Associative relations among the several stages and subgroups: Hyp. 1 is associated with (*i.e.*, "known" to) the hand-group of Int. but not with the voice-group. It is associated with Hyp. 2 and with Post-hyp. The voice-group of Int. is associated with Hyp. 2 and with Post-hyp. The hand group is associated with both Hyp. 2 and Post-hyp., and partly dissociated (meaning of the writing) from the voice-group; and the two groups are reunited in Hyp. 2. Hyp. 2 is by suggestion associated with Post-hyp.

Comments: (1) The kinesthetic system of the writing hand is not dissociated from the voice-group. Even the touch system of the same hand can be drawn back by the aid of the visual function. (2) The abnormal character of Int. is indicated by the high degree of suggestibility. (3) The perseveration in the writing was independent of the form of the suggestion, so far as E

can discover, but O had seen similar results from another observer. (4) The problem-solving does not yield any evidence for co-consciousness. O thinks it was done in Int. and locates it very precisely, as between rising from the armchair and sitting at the table. E's questions were not sufficiently directed to this matter. So the nature of this highly interesting process is left in obscurity. (5) O interprets in Hyp. 2 his inhibitions in Int. as lack of desire. This is frequent enough as a delusion in hypnotic phenomena. (6) The cause for O's selecting an S from sixteen-forty-two (1642) as a date is obscure. (7) Closing the eyes during the act of writing seems to lessen dissociated activity. (8) In Int., O feels less aware of his body than in Post-hyp. (9) Spontaneity in hypnosis is shown by the selection of a particular letter to be seen in the palm of E's hand; but that choice is evidently closely related to an earlier number suggestion of E.

Section 2. Experiments A–C

(This group of three experiments conforms to the Dissociation Test, but is defective in other tests of our canon. The probative value seems, however, to be high.)

EXPERIMENT A.

April 13, 1920. Probably about 3:30 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.
(This is the third experiment in hypnosis with this observer on this date.)

Hypnotic Stage:

O was asked whether there was any poetry which he could repeat from memory. He mentioned Coleridge's Ancient Mariner, saying that he could repeat about fifteen verses (?) beginning at Part II. He was told that on awaking he was to write them out.

Post-hypnotic Stage:

(Corresponding to the Interim Stage of other experiments, except that, in this experiment, there was no second induction of hypnosis.) O responds negatively to tests of suggestibility. He does not remember the events of the preceding hypnosis. After O takes his seat at the table and grasps a pencil, put into his hand behind the screen, E begins:

E: Does this suggest anything to you? O: No, but I guess I may have been told to write something. It is only a guess.

E: Do you remember what you had for lunch? O answers correctly as verified by his fellow boarder, R.

O is then given a copy of Aesop's Fables and told to read aloud at a designated place. He reads about six pages, clearly and intelligently, laughing at jokes. During this time his right hand has been producing the following confused and disjointed piece of writing—one of his worst. It begins with Part II of the Ancient Mariner, according to the suggestion, but skips about from point to point between Part II and Part I. The record does not show at just what juncture in the foregoing the writing began.

The sun now . . . east (an error, corrected in next line) | . . . *right . . . came heee* | . . . | . . . (For the next two legible words he goes back three stanzas into Part I) *albatross . . . follow . . .* (He then skips forward to the fourth stanza of Part II.) *God's* | *own head . . . then . . . averred . . . that* (incorrect insertion of conjunction) . . . | *killed the bird . . . mist* | (For the next two words he goes back many stanzas into Part I.) *and snow . . .* | . . . (He skips ahead several stanzas in Part II from the point previously reached in that part.) | . . . *Sun . . .* | (Next word is apparently a mere repetition. He started a new page with it.) *Sun . . . mast copper* | *sky.* (This is the confused representation of the following:

"All in a hot and copper sky, the bloody sun at noon, right up above the mast did stand." Then a skip over one stanza.) *Water water everywhere* | (Then reverting several stanzas) *and I had* (then back to the "water" stanza again, using a wrong but frequently quoted turn) and *not* . . . | (the next line written from right to left) | . . . | . . .

At the close of the foregoing writing, tests for suggestibility were negative except in the concealed writing hand where they were positive, though O supposed he was resisting them successfully there as well. This hand was also anaesthetic to the wrist. Once he failed to execute a command with his right hand, though declaring he had done so. Once when his right hand was touched, in the test for anaesthesia, he located the touch in his right hand. Repetition showed him to be in doubt and that his locating was inferential. He said it must be his hand since the place touched was the end of his arm. Feeling was restored by telling him, when his eyes were closed, that after his left hand should have been touched by E, he could experience feeling in his right. He could now resist suggestions, whether his eyes were open or shut; but his right hand seemed to him to feel no different. He stated that he had paid no attention to his right hand while reading; that the reading was quite easy; that he was very much interested; and that he could remember what he had read, speaking of the title (not specially tested so far as the record shows); that, further, his only knowledge of the act of writing was inferential.

He was then given the book and told to repeat the previous reading. He did so with no apparent difference. A few moments after starting, his right hand picked up a pair of compasses lying near and began making writing movements, apparently, on the table top. Stopping to turn a page with that hand, he kept it on the book.

A test with compass points, to determine whether an apparently chance thought of numbers could be really determined by the number of pressures given to the anaesthetic hand, was a failure. Not a single number reported corresponded exactly to the pressures given. The record was as follows:

Number impressed.	Number spoken.
4	27
6	16
7	51
2	81
4	41
1	99

Probative character of this experiment: O wrote fragments of once learned poetry, according to a previously arranged plan, while in some way not remembering what the plan was, nor aware, at the time, that he was writing, nor paying any attention to that hand. At the same time he was reading aloud intelligently in a manner not apparently different from that shown later when no writing or other suggestion was being performed. He appreciated the meaning of what he was reading well enough to laugh at its humor. He felt, as he later reported, that the reading was

easily done; he could recall it, and was much interested in it. He could engage in conversation and recall other facts of recent occurrence, all this performance being very different in fluency from those others in which the same O was trying to do several things at once (see Exp. X, 1, 3–5). The writing-hand system was so disconnected from the remaining system that O was deluded both as to what did and what did not happen to it.

The Memory and Perception Tests were not applied. The fragmentary nature of the writing indicates that the hypothetical co-consciousness was imperfect in function, though, to be sure, the illegible parts may really be the representative of the needful connecting ideas.

This evidence does not exclude the possibility that O, having chosen in Hyp. 1 the subject of his writing, executed the task without mentality. In the light, however, of the satisfactory evidences found in other experiments the disconnected function in the present experiment may be interpreted as psychic and the facts of it thus confirmatory of the hypothesis of co-consciousness.

Comment: (1) It is a matter of some interest to note that in all the experiment O's right hand felt in no way peculiar. He was aware of no dissociation, no alteration of function. (2) Feeling could be restored to the screened hand by suggestion from E. (3) The recurrence of automatic writing during the second vocal reading was self-initiated—due, perhaps, to its association with the earlier reading. The failure to get a record of this was opportunity neglected. (4) The felt signs of bodily self-control, whatever they are, may exist, apparently, regardless of the actual events in the member in question. (5) The failure to influence the choice of numbers contrasts with the success of other attempts to this end recorded among these experiments.

EXPERIMENT B.

May 5, 1921, 2:00 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: When you waken go to the automatic-writing table and write anything you like. You won't be aware of anything you are writing.

INTERIM STAGE:

E: Do you feel as though you had had a deep sleep (objectionable as a leading question)? O: Very much so. (In Hyp. 1 had occurred the experience reported at the end of the record of May 3, 1921.)

O took his place at the table, and put his right hand behind the screen, talking as he did so about the students' celebration of the preceding night. This continued some minutes as a conversation between O and E. O was slow to begin writing—or E to note it. At length E observed that O was making writing movements with his fingers, which had not yet grasped the pencil. Thereupon E slid the pencil along until it came into contact with O's hand. Then O promptly picked it up and began writing at once. During a short pause in the conversation, before the pencil-writing began, a far-away look settled briefly on O's face. His hand wrote as follows:

What are you thinking about | . . . *what are you thinking about* | *why* . . . *I want* | *to be asleep. I don't like to* | *I know* . . . *I know what* | . . . *what I am writing about* | *I am happy when I'm asle* (runs off paper) | *happ asleep—happy asleep* | *happ aslep. when I am* | *aslep* | *whe when I'm* |

The following dialogue, occurring after the conversation aforesaid, influenced the writing:

E: Are you awake or asleep? O: Awake—pretty much so; (and, in reply to more questions) not wide awake; not so wide awake as when I first came into the laboratory.

Tests for anaesthesia of writing hand with a knife-point and of other parts of the body with E's finger gave positive results for the hand in question. O could not control that hand, though he thought he could; it accepted E's suggestions, while the left hand did not.

E: What have you been doing? O: Talking to you about things (enumerating all the topics).

E: What else? O: You have been touching me. I have been doing, or not doing, the things you told me to (referring to tests of motor control, evidently). I've been sitting in the chair.

E: Is that all? O: Yes, but I can guess a lot.

E: Well, guess. O: That's hard work, too.

Lack of time made E hurry on without following this lead further.

HYPNOTIC STAGE 2:

E: What were you doing at the desk (table was meant)? O: Writing.

E: What else? O: You were touching my hand with a pin or something.

E: What were you writing about? O: Nothing in particular. You told me to write anything I wanted to.

E: Did you? O: Oh yes, but I didn't want to.

E: What did you write? O: Happy while I was asleep (correct). I wrote the question you asked me first (*i.e.,* just before O was wakened from Hyp. 1, viz: "What are you thinking of now?" (correct); what I was writing at the table (viz: "I know what I am writing about." The exact meaning of this reference in the record is not clear. Perhaps this clause, taken here as a third identification, should rather be considered explicative of the second assertion. In that case it would be equally a true report of facts, since E had asked, in Hyp. 1, this question also: "What did you write about?").

POST-HYPNOTIC STAGE:

E: Do you remember anything about what has happened? O: No.

E: Do you remember about sitting at the table? O: Guess so. I don't know whether I remember it or whether you suggested it (referring, it seems, to the possibility of a post-hypnotic suggestion).

E: Do you remember anything that happened while at the table? O: No—just talking—don't remember what about.

E: Is that all you remember about it? O: You were talking about the baseball trip.

E: Were you talking about it, too? O: Yes.

E: Do you only remember talking? O: Yes. Oh! you were telling me I couldn't do things and I could. That's all I remember.

Probative character of this experiment: O wrote on topics spontaneously chosen, while, in some way, unaware of so doing as well as of a special stimulus applied to the writing hand, and, indeed, occupied at the same time with animated conversation, yet he recalled afterward the content of the writing and the special character of the stimulus, though meanwhile without any source of information other than the original experience.

This evidence is called confirmatory rather than probative, because, by itself, it does not exclude the possibility that O chose his topics in Hyp. 1, executed the writing without mentality, and recalled in Hyp. 2 merely what he had known in Hyp. 1.

Associative relations among the several stages and subgroups: Whether Hyp. 1 was associated with ("known" to) the voice-group of Int. was not tested; this connection existed with the hand-group; also with Hyp. 2, but not with Post-hyp. In Int. the hand-group was dissociated from the voice-group, though not completely, it seems ("I can guess a lot"—but "that's hard work, too," from the voice-group). The hand-group persisted in Hyp. 2. The only evidence that the unity of the partial groups had been restored is in the fact that the voice function was acquired by the hand-group. No test was made as to the retention of the voice-group experiences. In Post-hyp., however, only the voice-group survives. There is no trace of Hyp. 2.

Comments: (1) The peculiar feeling in Int. of being awake but not wide awake appears again. (2) Though the control of the writing hand was actually lost, it did not seem so to O, who had the illusion of control over it. It is regrettable that O was not questioned in Hyp. 2 in such a way as to discover whether there existed any latent knowledge of the real situation. (3) O preferred the hypnotic sleep to the dissociated functioning of Int.

EXPERIMENT C.

May 21, 1920, 2:45 P.M.

O: F. W. A. E: G. E. H. R: H. W. L.

HYPNOTIC STAGE 1:

Directions to O: When you awake you will have a chance to write automatically. You will be shown a paper with digits. For each digit you will make the corresponding number of marks, circles for black-ink digits, crosses for red-ink digits; arranging them in order under the preceding marks. You will not remember anything.

INTERIM STAGE:

The record does not show at what point in this stage O took his place at the table. The usual conditions of automatic writing were maintained, as shown in the conversation of Hyp. 2.

E: What do you remember? O reports correctly experiences that were tests of the depth of his hypnosis. "Then after I sat down I woke up." (The writing suggestion is evidently not recalled.)

E: Why did you wake up? O: I don't know.

O is now shown the number 246, the 4 being in red, the other figures in black.

E: Do you remember it? O: No.

E: When you were sitting with hands clasped, did you actually struggle to take them apart (referring to a suggested disability in Hyp. 1)? O: Yes.

E: What does it feel like to be hypnotized? O: Somewhat like going to sleep.

E: Do you notice other things beside my voice? O: Naturally.

E: Do you pay attention to them? O: No.

E: Did you feel different in hypnosis from out of hypnosis? O: I do somewhat, I don't know exactly how. I don't notice anything when I'm hypnotized except what I'm told.

E: Are you asleep or awake? O: Awake.

Tests for suggestibility are here negative.

E: What are you doing now? O: Answering questions.

E: What is your right hand doing? O: Moving about a little bit. I imagine the pencil is making chicken marks on the paper. (He is evidently not aware of the meaning of what his hand is doing.)

Tests showed that the right hand was not anaesthetic. Meanwhile that hand had been writing. It did not produce what O was told to do, but something that clearly had been determined by the suggestion. That writing follows:

I (might be "2") | *make* (might be "woke") | *nswer in 2 6* | ○ × ○ | *246.*

By the most favorable reading of the foregoing, it appears that O's hand is trying to show what it must do to carry out the plan on the basis of the number presented. The respective colors of the several digits have been noted and their bearing upon the execution of the plan. As the digits are black, red, black respectively, so the hand writes in effect: *I make* (a) *nswer in* (—Let's see!) *2 6* (both black—that means circle, cross, circle) ○ × ○ (that's the order for) *246.*

The writing stops at the point where O has determined the mode of applying the code; it does not actually carry out the suggestion according to that code. The cause of this interruption is not apparent. If, however,

the foregoing interpretation be tenable, we have a piece of evidence of equal value with the full execution of the suggestion; and showing the hypothetical co-consciousness at a different phase of its activity from any shown by the deciphered parts of the writing elsewhere presented in these experiments.

HYPNOTIC STAGE 2:

E: What happened in your first hypnosis this afternoon (*i.e.*, Hyp. 1)? O: I don't know.

E: Have you been hypnotized this afternoon before this? O: I don't think so.

E: What happened just before you went to sleep? O: I came to the laboratory—read a book on dreams—you came late. I sat in your chair with my arm behind the cardboard (*i.e.*, screen).

E: Were you doing anything when in the chair? O: My hand was making scratches on paper, probably automatic writing (but he declares a little later that he was writing nothing).

E: Does 246 remind you of anything? O: Yes, you showed it to me.

E: Does it make you recall anything else? O: A problem I did the other day for Henry (the present R).

(R asks:) Does red ink make you think of anything? O: The 4 was in red ink (correct).

E: What makes you think you were automatically writing? O: That's the way to do it.

E: Did I tell you to do any automatic writing? O: (Emphatically) No.

E: Do you remember the floor swaying (an hallucination of Hyp. 1 recalled in Int.)? O: No—when? I said something about it (correct).

E: When? O: Just before I was hypnotized (*i.e.*, the second time). I don't remember experiencing it.

E: What did you do before going to the writing table? O: I put dream book back and came back to the chair I am in now (always used for hypnosis).

E: What did you do when you sat down in the hypnotic chair? O: Nothing.

E: What was I doing? O: I have forgotten.

E: What did you write automatically? O: Nothing.

E: You said that you did. O: Did I? I don't know what it was.

E: Do you remember a problem you had to do? O: When?

E: Did you have one? O: Not this afternoon (correct).

POST-HYPNOTIC STAGE:

E: What do you remember? O: Talking to you—don't know what I was talking about. Something about the dream book (correct). I don't remember what. Something about chicken (correct—"chicken marks").

E: What did you say about it? O: Don't remember.

E: What else? O: I remember hurting finger with ring—your sitting down over there at the table—that I stood up, though I'm not sure. (Then, with emphasis) That's all I can remember. Very vague—all of it (applying, according to indications below, to Hyp. 2).

E: How many times have you been hypnotized? O: Two. I'd almost say three—I'd like to say it. (Is this a reference to some felt peculiarity of Int.?)

E: Why? O: I don't know.

E: What happened between the two hypnoses? O: I sat at the table

and did automatic writing, but I guess not automatic writing, for my hand was not anaesthetic. Probably just chicken scratches.

E: Do you usually make chicken scratches? O: Yes, a common thing.

E: Can you remember what happened in the first hypnosis? O: Yes (recalls correctly).

E: Which do you remember more clearly, the first or the second hypnosis? O: The first. The second is only vague; I felt way off, as though floating in air—a vast nothingness around me. I have felt that same thing sometimes when going to sleep. My skin felt numb when I woke up. I feel all right now.

Probative character of this experiment: If we are allowed to take the most favorable interpretation of the script, we have here evidence that lacks only the Memory Tests to be strictly probative according to our canons. O being unaware of the meaning of the script he is producing, and forgetting the original plan provided by E, gathers and interprets data according to that plan, and expresses by his script what he is doing. At the same time he is taking an intelligent part in a conversation, largely on a different theme. He does not, however, carry out E's plan in its entirety, nor can he afterwards recall either that plan or the meaning of the script.

Associative relations among the several stages and subgroups: Part of Hyp. 1 is associated with ("known" to) the voice-group of Int.; another part with the hand-group. Dissociated from Hyp. 2 it reappears in Post-hyp. The voice-group of Int. is associated with Hyp. 2 and Post-hyp., while the hand-group does not reappear. Hyp. 2, felt as very deep, is but slightly associated with Post-hyp.

Comments: (1) The vigor of dissociation in Int. is shown by the fact that neither the critical number nor talk about O's right hand suffices to bring to his mind the suggested plan and its execution. (2) The absence of anesthesia from the writing hand shows that the dissociated group has drawn less than usual upon the dominant group.

Section 3. Experiments K–Q

(This group of seven experiments is defective in the Dissociation Test.)

EXPERIMENT K.

April 15, 1920, 3:45 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

The third experiment (second in hypnosis) on this observer during this session.

Hypnotic Stage 1:

Directions to O: You will multiply two numbers. The first is 287; the second is the number of wooden spindles in the chair opposite you (not visible, of course, until he was wakened. E cannot say that O had never counted these spindles, but E who saw the chair much more frequently than O had to count them for this experiment). You will give the answer when rehypnotized, raising your hand as soon as you begin to think of the problem. (Directions repeated; then) Do you understand? (Affirmative reply.)

Interim Stage:

E: Can you recall anything from this recent hypnosis? O: No.

E: What did it seem like? O: I have no cue to begin with. I don't feel that there is anything there to put my finger on.

He was then asked if various objects in the room reminded him of anything; and then:

E: Does that chair (the critical one) recall anything? O: Yes—sitting there in the previous experiment, seeing it when coming into the room.

E: Anything else? O: No.

Hypnotic Stage 2:

(But see below for the probable time of its beginning.) O showed no tendency to do or say anything despite the original suggestion; and so E began to question him.

E: What is it? O: What is what?

E: What is the answer? O: Answer to what?

E: Recall what took place in the recent hypnosis. O: I don't remember anything of it.

E then began to suspect—what proved to be the fact—that O had not been rehypnotized. He was still in the Interim Stage, presumably. The following introspection concerning his psychic state was written by O either at once or, more probably, at the close of the expreiment: "On the unsuccessful attempt to induce hypnosis I looked at the shiny ring held above my eyes until it seemed much easier to close my eyes than to keep them open. My eyelids felt very heavy as they always do at this stage. So I closed my eyes, but was by no means hypnotized. As well as I can remember, in previous experiment closing my eyes does not mean I am hypnotized. Then (*i.e.*, in the experiment which occasioned this intro-

spection), 'drowsy, sleepy' was suggested, which *does* make me feel that way; but never do I lose consciousness of my environment or of myself. As nothing more was suggested, I did not fall asleep at all. I think that the suggestions 'now go deeper' and 'you're going down, down, down,' etc., must be the ones that finally induce hypnosis; as I lose track of space, body, etc., but feel as a particle in a vast space without top, bottom, or limits. Usually at first I have a falling sensation, generally accompanying the word 'down,' and at last forget all direction."

Hypnosis being finally induced, O raised his hand and said "1496" (incorrect, but see below).

E: Why did you say that? O: It's the answer to the problem.

E: What problem? O: 187 times the number of rounds (spindles) in the chair opposite (O seems to have misunderstood the first number as given, which was 287. With the data he alleges, his answer to the problem is correct, the number of spindles being 8).

E: When did you get the number of rounds? O: While talking with you.

E: Did you know you were looking at the chair particularly? O: No.

E: When did you do so? O: Almost immediately upon opening my eyes.

E: Do you remember anything else that happened? O: Yes, being given problem, going to table, reading and writing (all in an earlier experiment).

E: Do you remember anything outside the hypnotic sleep? O: Yes (going on to enumerate various topics of conversation occurring that afternoon).

E: You will remember everything that has happened during this experiment. Do you think you can? O: I don't know.

E: Why? O: Because I always forget.

POST-HYPNOTIC STAGE:

E: How do you feel? O: Different from the hypnotic state.

E: What do you remember? O: Giving the answer to a problem (correct).

E: What was it? O: A number in four figures—14—something (correct so far as it goes). I can remember things in time sequence only (meaning not clear).

E: What else do you recall? O: Telling problem and how I got the answer (correct); but I don't remember the actual getting of the numbers.

E: How were the numbers present in your mind? O: I saw them.

E: Do you remember raising your hand? O: No.

E: Do you recall anything else? O: I remember being told to remember (correct).

Probative character of this experiment: Having forgotten the plan provided by E, O gathers data according to it, while in some way unaware of so doing—at least not being reminded of it *immediately afterward* by having his attention called to the source of data. Yet later he recalls what he did, without having had access, meanwhile, to any source of information outside himself, and states—what is important but objectively unverified—that he obtained the data while talking with E, not knowing that he was looking particularly at the source of the data.

The possibility is not excluded by objective evidence that O obtained the data in an alternating state, *i.e.*, one forgotten immediately afterward. The evidence O offered from introspection may conceivably have been by itself an illusion of memory. The solution of the problem may have taken place after the beginning of Hyp. 2 and, in turn, requires no assumption of co-consciousness.

Associative relations among the several stages and subgroups: Hyp. 1 is dissociated from (not "known" to) the dominant group of Int., but causally connected with the hypothetical subdominant group and Hyp. 2; and dissociated, again, from Post-hyp. The dominant group of Int. is associated with Hyp. 2, and partially with Post-hyp., if, as is possible, the introspection was written at that time. O could not, however, recall in this stage the act of getting the number of spindles, though he had recalled it in a preceding stage. The subdominant group is dissociated from (not "known" to) the dominant group at least immediately after it has functioned. It is associated with Hyp. 2 but dissociated from Post-hyp. By aid of a suggestion, Hyp. 2 is partially associated with Post-hyp.

EXPERIMENT L.

April 29, 1920, 4 P.M.

O: H. W. L. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: You will multiply two numbers. The first is 473; the second is the number of spindles in the back of the chair opposite (not visible, of course, while O is in hypnosis, because his eyes are closed). When rehypnotized, you will give the answer immediately, raising your hand as soon as you think of the numbers: (Directions repeated; and then) Do you understand? (Affirmative reply.)

An amnesia suggestion also for the task in question was given. The number of spindles was 8—or 9—see below. E cannot say that O had no knowledge of this number prior to this experiment, but of his probable ignorance see "Directions to O" of Exp. K (15 April).

INTERIM STAGE:

E: Can you remember what happened? O: Yes (proceeding to enumerate correctly various occurrences during E's attempt to test O for depth of hypnosis, including some introspective account of these experiences; then) Seems as though there was something else, but I can't think.

E: Did your sensory experiences feel real? O: Yes. I feel as though there was something else to remember that I can't recall.

E: Would five dollars be an inducement to remember? O: Yes—more material. (But E did not make the offer. It should also be noted that E failed to develop an effective line of questioning to test whether the execution of the suggestion was a dissociated function.)

HYPNOTIC STAGE 2:

O raises his hand; shows effort, knits his brows, etc.; then says "four, three, five, seven." (Incorrect, but see below. The error does not seem to invalidate the experiment, as, despite this, the answer so closely follows the plan.)

E: What is this? O: Answer to the problem.

E: Why did they come in that order? O: Came in my mind that way.

E: (Wishing to make sure) How did they come? O: 4, then 3, then 5, then 7.

E: How did they appear? O: I saw them as white figures on a dark background. They just came out (*i.e.*, apparently without effort on O's part).

E: Did you make them come out? O: No, they just came.

E: How did they happen to come? O: I don't know; they just came.

E: How many spindles were there? (A blunder in questioning. The fact that spindles had been in question should have been evoked. This blunder partly interferes with the application of the Positive Memory Test.) O: 9. (Incorrect according to R's record. The laboratory has a 9-spindle and an 8-spindle variety of chairs; and it is just possible that R made an error. On O's count of the number, the correct answer is 4257, instead of 4357 as he gave it. These errors do not seem to invalidate the experiment, because the original plan is so obviously involved in spite of them.)

E: Did you do multiplying? (Another blunder in questioning, of the same type as the foregoing.) O: I don't think so. I didn't multiply them.

E: Is your answer to the problem correct? O: Yes.

E: How do you know? O: It came to me that way.

E: Did it take any effort on your part? O: I don't think I multiplied them.

E: Did you feel any effort? O: There seemed to be an effort just before I saw the figures.

E: What sort of an effort? O: I could feel it in my head.

E: When did you get the number of spindles? O: I don't know. (But see answer to same question below.)

E: When awake last, did you remember this problem? O: I don't know.

E: Did you know what that "something" was, when you said that something was there which you couldn't recall? O: I don't remember. (But see answer to same question below.)

E: Do you remember anything about your state when last awake? O: I know who was in the room. You asked me what I remembered, and I told you (saying this with difficulty); but I told you there was something I couldn't seem to recall (correct).

E: Why couldn't you recall it? O: I couldn't think of it.

E: Do you know what it was? O: About the problem you gave me to do. (Could this have been objectively verified—as of course it could not—it would be important evidence of co-consciousness.)

E: Are you asleep or awake now? O: I think I am awake; I don't feel asleep.

E: But when you talk you will stutter. (O, thereupon, cannot speak without stuttering, showing that he is really in hynosis.)

E: Was that experience like being awake or asleep? O: I don't feel awake or asleep.

E: How do you feel when asleep? O: I don't think when asleep.

E: Are you now? (This too abbreviated sentence may have referred to the act of either sleep or thought.) O: Yes.

E: Do you hear these voices, noise of train, etc.? O: I hear you. I don't seem to hear anything (else) but rustlings. (A student visitor in the room at the time was then made to address E by name. O heard him speak, and adds:) It seems as if I was in a fog—not awake. (He takes in a breath with a shiver.)

E: Do you feel cold? O: My hands are.

E: How did you get the number of spindles? O: I suppose when I looked at the chair. I don't remember looking at different parts of it.

E: Did you hunt for the spindles? O: No. I wouldn't have any reason to. (Could O, from his previous acquaintance with the laboratory, have known in advance of the Interim Stage, the number of spindles, making it unnecessary to assume any attempt to get this fact in this stage? This possibility is not formally excluded. It is formally possible that participants in an experiment a fortnight before, when the same choice for multiplier was used, may have mentioned it to O. With his honesty beyond question, however, it seems impossible that he should have replied as he did to questions in the Post-hypnotic Stage, without also mentioning such information already obtained, if he possessed it. It is regrettable indeed that the conditions of this experiment did not formally exclude all these possibilities. And may we not also urge that O's inability to recall such information in the Post-hypnotic Stage was merely a case of dissociation? This is a gratuitous assumption not warranted by anything known to E about that stage. The belief seems thus valid that the alleged possibilities are not real.)

Post-hypnotic Stage:

E: Can you remember what has happened? O: Yes—giving you a number.

E: What sort of a one? O: I think it was 4537 (really 4357). You asked how I got it and how I got the number of spindles in the chair.

E: Does it seem easy to revive these memories? O: Some things stand out more than others. I can't seem to remember everything. It seemed as though the numbers drew across in front of my eyes. They didn't just appear suddenly; they semed to move across in front of me.

E: Do you recall about the chair spindles? O: I can't remember when I got them or why I should get them. I remember looking at the chair, but I didn't pay any attention to it.

O adds the information that he is not good at arithmetic.

Probative character of this experiment: O gathers data according to a plan furnished by E, though in some way not aware of the plan. Later he recalls that there was a plan, which in Int. he was vainly trying to remember. He recalls the data, without access to sources of knowledge outside himself; also that he

looked at the source of the data, but paid no attention to that object and did not look for the data.

There is no objective evidence that the actual gathering of the data was a dissociated function; nor is there evidence that O afterward recalled the gathering of the data or what special treatment he gave them. The subjective evidence of dissociation (*i.e.*, the evidence from memory) is definite, but that might have been a mere physiological disconnection, so far as this experiment shows. It is only in the light of other experiments that the facts here brought forward can be regarded as properly explicable in terms of co-consciousness and so as confirmatory of that hypothesis.

It should be noted that but for E's blunders and omissions stronger evidence might have been available.

Associative relations among the several stages and subgroups: Hyp. 1 is almost completely associated with ("known" to) Int., the exception being the group of items concerning the problem—a group included within the amnesia suggestion. This group was represented by a disconnected function in Int. but yet was not wholly dissociated. O was aware of something there to be recalled. Hyp. 1 is also associated with Hyp. 2. There is no evidence as to its survival in Post-hyp. Int. is associated with Hyp. 2 and its dissociated functions in part reunited, but only the dominant group persists in Post-hyp., so far as the evidence goes. Hyp. 2 is well associated with Post-hyp.

Comments: (1) The mode of solution of the mathematical problem is left an interesting puzzle. O has no introspection that sheds light on this. The performance seems to have taken place at the beginning of Hyp. 2, and, so far as the evidence goes, one is left to speculate as to whether it was a purely physiological, or also a mental, process. The end-product alone comes into view, as visual images of the digits that make up the answer. The introspection leaves it in doubt as to whether at any time the digits were all present together; and, if so, as to whether they were arranged in the space order usual to the four place number intended. (2) It is apparent that a greater skill in questioning than E displayed might have cleared up some of the obscure

places in the experiences here under examination. (3) O's attempt to describe what hypnosis feels like shows uncertainty and is contradictory. (4) The persistent inability to recall the act of getting the number of the spindles may be due to the particular form of the amnesia suggestion in Hyp. 1. The precise words in which this suggestion was given are not a part of the record. At first the entire group of items to which the suggestion was intended to reply was inhibited. Why, later, this item alone should remain persistently hidden is so far inexplicable. (5) O's depth of hypnosis was not such, in this experiment, as to insure amnesia for its events, without the aid of a special suggestion to that effect.

EXPERIMENT M.

May 4, 1920, 1:30 P.M.

The O was P. J. The record is not clear as to E and R. G. E. H. was by turn both E and R. H. H. assisted as E; and so probably did some one else.

HYPNOTIC STAGE:

Directions to O: You will multiply two numbers. The first is 85; the second is the number of shelves in the book-case to the right of the door (facing him as he sat). When you are re-hypnotized, you will give me the answer at once, raising your hand the moment you begin to think of the problem. (The number of shelves was 12. It is probable, though not certain, that this number was unknown to O, as the room was nearly surrounded by high cases, having varied numbers of shelves and O had but rarely been in the room.)

INTERIM STAGE:

O remembers the voice of the hypnotizer and the stroking of his own forehead but not the problem. (The record mentions no attempt to watch O's behavior during this stage, nor to test whether he knew he was learning the number of shelves.)

HYPNOTIC STAGE 2.

O delayed so long to give the answer that he was asked—"Have you anything to tell me?" O replies "1020" (correct). At first, in answer to questions, he showed ignorance of both problem and its relation to the book shelves; but finally he remembered them and 85. He got the number of shelves while awake, he said; but he did not then know he was counting them nor anything about the problem.

POST-HYPNOTIC STAGE:

E: Why did you wake when you did? Just felt like it.

E: Can you remember anything that happened? O: I remember saying 85 and your telling me to wake up.

E: Why didn't you wake up when Dr. B..... told you to? O: It didn't penetrate; I didn't feel like doing it. (Dr. B..... came into the room while the experiment was in progress.)

E: What else do you remember from the second hypnosis? O: Nothing.

E: What do you recall from the first hypnosis? O: Nothing.

Probative character of this experiment: According to a plan provided by E, O obtains a number by counting objects, whose number he probably did not already know. Though forgetting the plan he gets the number; but whether at that time he knew what he was doing we cannot by objective evidence say. Yet, afterwards, in recalling, without any outside assistance, that he had gotten it, he asserts that he had done so unconsciously and was also then unaware of the problem.

EXPERIMENT N.

April 13, 1920, 1:45 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

HYPNOTIC STAGE 1:

Directions to O: I am going to give you two numbers to add together. The first is 147, the second is the number of lines in the paragraph I shall give you to read on awakening. You will give the answer as soon as you are rehypnotized, raising your hand the moment you begin to think about the problem. You will forget everything (E meaning by this, the events of Hyp. 1) on awakening. (Directions repeated; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

Being asked to recall everything that had happened, O could remember only the suggestion of sleep at the induction of hypnosis, and the number given to awaken him. (E counted three.)

E: Put your mind on it. O: I don't know where to begin to think.

He was then handed a copy of Aesop's Fables and told to read aloud a designated one of 24 lines, of which one line had but a fraction of a word. The reading required that one page be turned. He read rapidly and clearly, beginning at once and looking up as soon as he had finished. The volume was immediately taken away from him.

HYPNOTIC STAGE 2:

In 50 seconds after rehypnotizing began O raised his hand and said 169, the correct answer being 171. Though erroneous, this answer seems to be so close to the plan already known to E as not to invalidate the experiment. The error, as shown below, was in counting the lines, the computation was correct.

E: Why did you raise your hand? O: Because I was told to.

E: When did you raise it? O: When I thought of the answer. (According to directions, he was to raise it the moment he began to think about the problem.)

E: What were you doing before you thought of the answer? O: Nothing.

E: What were you thinking? O: Nothing. (In the light of the answer to the later question about adding, the two foregoing replies must be held to refer to Hyp. 2.)

E: Where did the answer come from? O: The sum of the two numbers.

E: What two numbers? O: 147 (correct) and 22 (incorrect).

E: Where did you get 22? O: It was the number of lines in the paragraph I read.

E: When did you add the two numbers? O: After I had finished reading.

E: Before you were rehypnotized? O: Yes.

E: Were you aware, at the time, that you were adding? O: I wasn't thinking about it.

E: If you had been asked, at the close of the reading, whether you were adding anything, what would you have said? O: I would say no.

E: Why? O: I was not thinking of what I was adding.

Then followed a brief shift in type of questioning, occasioned by a problem raised by a fellow student with O in Psychology. He had brought to E's attention a difference of memory between them as to the gown worn by a cousin of O on the occasion of a recent visit paid to her by the two young men. The friend, who was strongly convinced that he was right, wondered whether O, in hypnosis, would likewise have a correct (?) memory of the fact.

E: Do you recall the colors in your cousin's dress when you visited her at the hospital during the holidays? O: Yes.

E: What were they? O: Dark blue dress with buff colored girdle and intersecting circles all over her dress.

E: Of what color were the circles? O: Buff.

At the end of the afternoon when experimenting was ended and O out of hypnosis, he was again asked to tell the color of this gown. He replied: Medium light blue with very dark blue intersecting rings all over the dress; the girdle of buff color. He added that he had had an argument about this with the friend mentioned above, the latter maintaining that the rings matched the girdle and that the dress was dark blue. Unfortunately the record does not state whether this was indeed the friend's recollection, nor what were the actual facts about the gown. There is no doubt, however, that O had very different recollections in and out of hypnosis, respectively; and that in both cases he expressed himself with equal promptness and apparent conviction; and that, further, according to his own statements, his hypnotic memory agreed with his friend, while his waking memory disagreed.

E: What do you think about between your attempts to answer my questions? O: I don't think of anything.

POST-HYPNOTIC STAGE:

O could recall nothing which had happened in hypnosis, but from Int. he recalled reading the fable and the number of the page. (This number had, however, been mentioned within his hearing in that stage.) He had but vague memories of the story of the fable. He thought his mind must have been on something else, but he could not remember what? Being told to read it aloud again, he did so, no difference in method of reading being apparent between the two. "Yes, I remember it now," said he.

E: What were you thinking about during the previous reading? O: I don't know. I must have been reading words without getting the meaning.

E: How does that happen? O: I don't know.

To observe his normal power of recall, E gave him another fable to read aloud. Before he had quite finished reading, an interruption occurred in the form of an arrival with whom some necessary conversation took place in O's hearing. In spite of this distraction, he repeated the story very clearly, showing good recollection.

Probative character of this experiment: While reading a text in an apparently intelligent manner, O obtained a number according to a plan already known to E. No test was made as to whether O had a clear idea of what he was reading though his manner of doing it was normal, in contrast with the check experiments of Part IV; nor as to whether he was aware of getting the desired number—grave omissions, both. Later, he recalled the number and when he got it, without having had access, meanwhile, to any source of information outside himself. He also reported that, in the same Interim Stage, he was adding the numbers without being aware of it. This introspection, fully indicative of co-consciousness, could not, of course, be verified objectively.

Associative relations among the several stages and subgroups: Hyp. 1 is dissociated from the dominant group in Int. but not from the (hypothetical) problem-group. It is associated with Hyp. 2 but not with Post-hyp. The dissociated groups (if there be two) of Int. are reunited in Hyp. 2. In Post-hyp. the dominant group survives very scantily, and the problem group more scantily still—a vague somewhat, if at all. Hyp. 2 is not associated with Post-hyp.

Comments: (1) A little new light is shed on the puzzling question of the problem solving function. Subjective evidence is offered that it takes place as a dissociated operation in Int. The attempt to use the hand-raising suggestion as a means to determine when the computation takes place is again futile, since—as O asserts—it is not raised until the answer is ready. This seems to be a curious disregard of an hypnotic suggestion. (2) The felt emptiness of "between times" in hypnosis is again evident. (3) The contradiction between the hypnotic and the waking memories of a given fact is chiefly interesting, perhaps, in its indication of a mode for investigating special causes of falsification. E was strangely blind to the possibilities when he broke off his questioning where he did.

EXPERIMENT O.

May 18, 1920, 3:15 P.M.

O: P. J. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: I am going to give you a problem,—to add two numbers. The first is 487 (understood by O as 277, if his recollection may be trusted); the second is the number of words in the first line of the paragraph you will read after awakening. You will write the answer automatically, and remember nothing of what I have now said. (Directions repeated; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

Thinking with obvious effort, O gave a few recollections of the preceding stage, some of them incorrect; and finally added: "I can't seem to think very well." Taking his seat at the table, with a pencil in his screened right hand, he was given a particular paragraph to read. There were 8 words in the first line. After reading awile (whether vocally or silently, the record does not state) he said: "I thought of something, can't think now."

E: What is it? O: I am trying to think.

E: Of what? O: I don't know—of nothing (and he continued reading).

E: Do you recall anything more? O: I just thought of something a moment ago—I don't know. (He complained of being hot.) You told me to do something and I turned my head around. No, I can't remember.

Meanwhile O wrote 285 once. (This answer is incorrect according to the actual data; but according to O's recollection of the data, as shown below, correct.)

HYPNOTIC STAGE 2:

E: Can you tell us what you were trying to remember while sitting in the chair? O: (Repeating the last part of the question) To remember 277. That was a number you gave me.

E: What else? O: You wanted me to write something; you wouldn't tell me what it was (correct).

E: What were you doing, sitting in the chair? O: Reading about the grasshopper, the ass, and the donkey (only partly correct and combining two fables). I held a book and a pencil. I wrote a number—285 (all correct).

E: Why? O: There was 277. Write it and add to it the number of words in the first line of the paragraph (partly incorrect).

E: Why didn't you tell me when you were sitting in the chair? O: I don't remember your asking me. (No specific question put—only general.)

E: Do you remember writing? O: Yes, now. I didn't know I was then. (His statement on this point below is a little more guarded.)

E: What were you trying to remember? O: 277 and words in the first line. I didn't know it then, I just found out now.

E: Did you know you were writing it then? O: Now I do. I didn't remember (*i.e.*, notice?) then whether I was or not, don't think I do (did?).

This pretty large emendation is offered, subject to correction. The record, without some change, seems meaningless.

E: How can you remember now and not then? O: (Screwing up his face) Just forgot.

E: Why do you screw up your face so? O: Trying to think.

E: Are you asleep or awake? O: Don't know—hands are awfully heavy.

E: Why didn't you tell me about it then? (Reference uncertain.) O: Didn't notice it then.

E: Why were you so slow in falling asleep the first time (*i.e.*, to-day)? O: I couldn't focus my eyes.

E: Why so quickly the second time? O: Don't know.

E: Are you asleep or awake? O: Don't know. I feel both asleep and awake.

E: You can't recall your name. O: I can think of it, but I can't say it.

E: When you say it you are going to stutter. (O accepts the suggestion, after his face works and his mouth twitches.)

Being given the usual suggestion to waken, he does not accept it at once, saying that his hand is heavy. The suggestion being repeated in a few minutes, he then comes out of hypnosis.

POST-HYPNOTIC STAGE:

O recalled that he had laughed without being able to stop (probably a test for depth of hypnosis). He reported nothing else.

Probative character of this experiment: O gathers information and puts it to use according to a plan provided by E, in solving a problem and writing the answer. Though it has some effect on his dominant state, this state seems to be unaware of the function in question and occupied with reading. The objective evidence is not adequate for the conclusion that this function was not a part of the dominant state, though if, once a part, it was immediately forgotten. But later, when recalling, without objective assistance, problem and data, and writing the answer, he asserts that at the time of performance he had been ignorant of data and writing.

Associative relations among the several stages and subgroups: By aid of a suggestion, Hyp. 1 is mostly dissociated from (not "known" to) the voice-group of Int., but not from the hand-group. It is associated with Hyp. 2, and in small part with Post-hyp. The subgroups of Int. are reunited in Hyp. 2 but disappear in Post-hyp., as does Hyp. 2.

EXPERIMENT P.

May 20, 1920, 1:45 P.M.

O: G. E. H. E: C. T. B. R: H. W. L.

(The only excuse and explanation E has to offer for his serious blunders in method, in this otherwise unusually interesting experiment, is his own surprise at the developments. They apparently made him forget his main purpose.)

HYPNOTIC STAGE 1:

Directions to O: I am going to give you a problem. You will add two numbers. The first is 637. The second is the number of pages you will have turned over in a book to be given you on waking when I tell you to stop turning. You will speak the answer automatically, as soon as you solve the problem, without being aware of what you have done. (Directions repeated; then) Do you understand? (Affirmative reply.)

INTERIM STAGE:

Receiving the book O turns the pages until, when told to stop, he has turned 13. He thereupon says 652. (Though incorrect, this answer conforms to the plan too well to invalidate the experiment.)

E: What? O: I said "The Ox and the Butchers." (The title of a fable was "The Oxen and the Butchers." Whether O really had said this also does not appear from the record.)

E: What was it? O: I said "The Ox and the Butchers." That was the first thing I said.

E: You are not aware of anything? O: No. (This question, because of its connection with the preceding, is not definite enough to cover the counting of pages. The omission of a supplementary question was a serious blunder in developing the evidence of co-consciousness, so far as the counting-computing function is concerned. If at the time of the performance he was aware of it, with no reservation in the meaning of the term, the hypothesis of co-consciousness is unnecessary.)

E: Are you asleep or awake? O: Awake.

E: Do you know the difference in feeling? O: Yes. I felt sleepy on first awakening.

E: When did you stop feeling sleepy? O: I guess it wore off gradually. I guess talking made me wake up.

A test of suggestibility was negative.

E: What does 13 make you think of? O: Nothing except unlucky number. (If he had counted wrong, this number would not have formed a significant part of his experience; and the question, in that case, would be of no value.)

E: Are you telling the truth? O: Certainly.

E: What does 652 make you think of? O: Nothing special, but it sounds familiar; it must have been 652.

E: What does 833 make you think of? O: Nothing.

E: Does that seem familiar to you as the other did? O: No.

E: What can you remember from the hypnosis? O: Nothing.

E: Would you prefer not to? O: No.

E: What is the last thing you recall in connection with hypnosis? O: I can't recall anything about hypnosis.

E: After fixing your eyes for hypnosis what happens (happened?)? O: I don't remember. I don't feel as though anything had happened—no transitional period between the two states.

E: Does 652 seem familiar? O: Sort of familiar.

E: Does 632 seem familiar? O: Yes.

E: You don't know why? O: No.

E: Does 13 seem familiar and, if so, why? O: Because it is a common number.

HYPNOTIC STAGE 2:

E: What took place just before you were hypnotized this time? (O gives no response even after being urged.)

E: What happened when you were hypnotized before? O: (After some urging) I don't know.

E: Is it hard for you to speak? O: Yes.

E: Why? O: I don't know.

E gives suggestions for ease in speaking. Again no answer from O.

E: What is the trouble? (O is silent.)

E: Pronounce your name. (No reply.)

E: What are you sitting on? (No reply.)

E: Say Bowdoin College. (No reply.)

E: If you know how to say it, raise your left hand. (No response.)

E: If you don't know how to say it, raise your left hand. (No response.)

This failure to raise the hand is hard to explain.

E: What are you thinking about? (No reply.)

E: Who is writing at the desk? ((No reply.)

E: Why are you unwilling to speak? (No reply.)

Tests for motor suggestibility of the limbs are positive.

E: Where were you at lunch today? (No reply.)

Happening to notice that O's right hand showed signs of writing, E sent him to the table, where, without verbal suggestion, O wrote his replies to the following questions, but maintained his former silence. His writing hand was probably screened.

E: What took place before you were hypnotized last? O: *I was turning the pages | of a book, and was to add the | number of pages to 637; | and the answer is 652 which | I said. And then I talked | with you, but I can't | now. because I said 65* (Here the writing runs off the paper.)

E: Why can't you talk to me? O: *because I said 652 | Because I can't say the words | now.*

E: Do you know what words are (*i.e.*, mean)? O: *Yes! | I can't think of them, or how to say them.* (In connection with his other statements, this seems to mean that he can't think words in vocal terms, but only in hand terms.)

E: Can you think of your name? O: *Yes.*

E: What is it? (He writes it correctly.)

E: Do you feel my touch on your hand? O: *Yes 3.* (Record does not show how many times E did touch the hand, nor which hand.)

E: How can I get you to speak? (O produces meaningless marks.)

E: Do you want me to waken you? O: *Don't care.*

E: Is this inability to speak like anything else you have ever experienced? O: No.

E: Will you try to remember this experience after you wake up, if I ask it? O: *Yes.*

E: Are you aware of what is going on in the room about you? O: *Yes since you asked me.*

E: I want you to try to remember how to say your name. O: *Can't No.*

E: Why? O: *I can't think . . .*

E: Please repeat what you just wrote. O: *Can't think how.*

E: Can't you talk to me? (O shakes his head.)

E: Would you like to talk to me? (O nods.)

He is then given a suggestion to remember, on awaking, what has occurred.

(A serious blunder in this Stage was the failure to ask O whether he was aware, at the time, of counting pages in the Interim Stage. This prevents the use of the counting-computing function as evidence for co-consciousness;

the function may have been a part of the dominant consciousness. An equally serious omission was the failure to ask O whether, at the time of speaking the number, he was aware of so doing. The source of the error in the number might also have been discovered, by asking O how many pages he counted.)

Post-hypnotic Stage:

E: What can you tell us about what has taken place? O: I have been writing answers to your questions.

E: Why write them? O: Only way to answer them.

E: Why the only way? O: Because I couldn't tell you, I had to write it.

E: Why couldn't you tell me? O: I sort of lost all sense of talking; I didn't know what it felt like.

E: Did it disturb you at all? O: Just a little at first.

E: How did you happen to start writing? O: I was writing all the time; it seemed the only way.

E: You did it before I put you at the table? O: Yes.

E: From the first question? O: No, I tried to answer the first question (*i.e.*, vocally).

E: How did it feel? O: Felt as though I had forgotten it, and also that I didn't want to say it.

E: Have you ever had an experience like it before? O: Yes, when very sleepy in the morning and some one tries to wake you up and you don't want to speak to them.

E: Do you recall anything further back than the last hypnosis? O: Yes. I remember looking at the pages of a book and giving answer.

E: Do you recall the number? O: Yes, 652.

E: Were you aware then of giving the number? O: I don't remember about that, but I recall remembering it.

E: When did you remember it? O: When you were asking questions about it in the second hypnosis.

E: You don't recall the original utterance of the answer? O: No.

E: Do you feel awake or asleep? O: Awake, but sleepy.

E: As awake as usual on coming out of hypnosis? O: Hard to tell.

E: Do you feel as you do when you accept my suggestions? O: No, not so sleepy.

E: What did you do with the book? O: I turned the pages.

E: Doing anything else with it? O: Yes, counting the pages.

E: Why? O: For the problem.

E: Did you know you were doing it at the time? O: No, don't think so (important had it been objectively verified). Things that happened then do not feel the same. I remember things then, after the first hypnosis, as I did during the second hypnosis. The Interim Stage does and doesn't seem different from the second hypnosis. I remember them in the same light. I don't know how to express it exactly—I remember what happened the first time (*i.e.*, in Hyp. 1), your giving the problem.

E: Do you ever remember things that you can't tell me? O: Yes, have an inkling, an idea that I can't express in words. I sometimes have ideas that flash through my mind and I forget them, much less can I say them, and these are quite forgotten later on. Some come up later that I couldn't recall at first.

E: Do you dream much? A: Rarely, or at least, I rarely remember them.

E: You many times tell me you can't recall. Do you usually in those cases have those inklings of which you speak? O: Yes, I think so, usually.

E: Is it like the feeling of losing a name? O: No, a different experience. I don't remember as much as that. It is hard to explain.

E: Still more vague than a lost name? O: Yes.

E: Think of a city of Central America beginning with T. O: I can't recall, but this feels different.

R asks: What is my sister's last name? (She is known to O, but has been married not long since.) O: I can't recall. Some (experiences in this experiment) seem like this: other attempts would be even less successful. This seems like the attempt to remember some of the hypnotic experiences; other attempts yield even less.

E: Do you still remember the difficulties with speaking? O: Yes, but I don't remember what it was like.

E: Does it seem like a possible experience? O: It doesn't seem possible; I can't quite imagine it.

Probative character of this experiment: O obtains data, performs problem, and gives the answer orally—all according to a plan furnished by E. During this time no dissociation test was given; but immediately after speaking the answer O had forgotten the utterance and could not recall that any plan had been given him. He later recalls the plan, counting the pages, speaking the answer, and the answer spoken, without, meanwhile, having had access to any source of information outside himself; and he thinks that at the time of counting he was unaware of so doing.

The chief defect in the foregoing evidence is in the Dissociation Test. The possibility is not excluded by the objective evidence that the plan was carried out in an alternating (rather than co-conscious) state, and straightway forgotten, though the subjective evidence, so far as it goes, favors co-consciousness.

Associative relations among the several stages and subgroups: By aid of suggestion, Hyp. 1 is not associated with ("known" to) the dominant group of Int., but is to some extent with the (hypothetical) vocalized-number group. It is also dissociated from Hyp. 2 (unless the first bit of writing be held to imply direct association), but associated with Post-hyp., with the aid, perhaps, of the suggestion given at the end of Hyp. 2. In Int. the vocalized-number group (if it exists) is almost wholly dissociated from the dominant group; is associated with Hyp. 2 and Post-hyp. The dominant group is reunited with the (hypothetical) vocalized-number group in Hyp. 2; it is also associated with

Post-hyp. Hyp. 2, in turn, with the aid of a suggestion to that effect, persists in Post-hyp., but begins to fade at the end of the experiment.

Comments: (1) The chief interest of this experiment attaches to the dissociation (or, if it be purely physiological, the disconnection) of a small vocal system, in Int.; and the spread of that system, in Hyp. 2, to include the entire speech apparatus—not merely the actual use of it but what such use felt like. In this observer, the hand-verbal system is evidently a completely functioning one, requiring no coöperation from the voice-verbal one. He seems able to think in hand terms; and to do so with ease. (2) O declares that he can't speak because he said 652, that is, apparently, because he followed the original suggestion to speak and not know it. Reporting on this later, he adds that he had the feeling of not wanting to speak. Was this a resistance to automatic speaking? (3) A feeling of sleepiness apparently accompanies the execution of the suggestion in Int. and disappears afterward. (4) O's failure to raise his hand as a code response to a question seems contradictory to the motor suggestibility evident a little later. Apparently, too, as the later developments showed, there was no failure to understand E's meaning. It remains unexplained. (5) In Post-hyp. O is able to recall from his past experience analogies to his vocal paralysis; but in the preceding Hyp. 2 he cannot. (6) In hypnosis O seems to neglect all stimuli that are not specifically brought to his attention by E. (7) He is not much disturbed by the vocal paralysis. (8) The felt likeness between Int. and Hyp. 2, as well as the fact of felt difference, is worth noting. (9) Speaking without sole reference to this experiment, O implies that there are fluctuations in degree of dissociation between simultaneous conscious systems; but these visitant " inklings " seem to be of the vaguest.

EXPERIMENT Q.

May 21, 1920, 4 P.M.

O: H. W. L. E: C. T. B. R: G. E. H.

HYPNOTIC STAGE 1:

Directions to O: I am going to give you a problem to multiply two numbers. The first will be the number of letters in the first proper name

I utter when you waken; the second will be the number on the left-hand page of the book I shall hand you, when I waken you. When you have performed the problem, you will speak the answer automatically, without remembering what I have told you. (Directions repeated; then) Do you understand? (Affirmative reply.)

Interim Stage:

Tests for suggestibility are negative. E then says: "George, will you give me that book? E hands it to O, open at page 86 (left hand). O turns over the pages and says (as R heard it) "416." (E heard it as 116, changed by O from 114, first uttered. The correct answer would be 516.) The utterance was in a low voice, but fully vocalized, not whispered.

E: What? O: I didn't say anything.

E: (Persevering) What did you just say? O: Nothing.

E: What can you recall saying so far? O: I remember saying that I didn't say anything.

E: Do you remember any titles you have just been over (referring to the contents of the book handed to O)? (He recalls some.)

Tests for suggestibility are negative.

E: Do you recall anything from the previous state (*i.e.*, Hyp. 1)? O: All I remember is a blank. I can't remember anything.

E: If I say that you don't want to remember anything, would that be true? O: No. I'd tell you if I could remember.

Hypnotic Stage 2:

E: What were you doing when awake just now? O: Looking at a book; talking with you. I gave you the answer to the problem (all correct).

E: What was it? O: 526. (The correct answer is 516, but the erroneous one is too much in accordance with the plan already known to E to invalidate the experiment.)

E: How did you get it? (O states the problem correctly.)

E: What was the first proper name I uttered? O: George (correct).

E: How many letters in it? O: Six.

E: What was the number on the page? O: 86 (correct).

E: How did you give me the answer? O: Automatically.

E: In what form? O: I spoke it (correct).

E: What did you reply when I asked you what you said? I told you I hadn't said anything (correct).

E: Was this true? O: It was when I said it.

E: Why? O: I didn't know I had said anything.

E: How could that be? O: You told me I wouldn't remember it.

E: Didn't you notice yourself saying it? O: No.

E: Did you know, at the time, that you were getting the number from George's name? O: No.

E: Did you do the problem as you ordinarily do (*i.e.*, as you would do it outside hypnosis)? O: I think so; I'm not sure. I can't recall multiplying anything.

E: How did you get the answer? O: It just seemed to come to me.

E: Though any particular sense? O: I could see it.

E: How did it look? O: It just flashed across in light letters.

E: Letters or figures? O: Figures.

E: Were you aware at the time of figures flashing across? O: No.

E: Can you recall events of the first hypnotic state? O: Yes.

E: Do you know what happens to those memories in the Interim Stage? O: You told me I'd forget them.

E: In the Interim Stage are you thinking of my statement? O: I don't know.

E: Then you may be thinking of it. O: I'm not aware of it.

E: Then why say you don't know? O: Well, I'm not aware of it at that time.

E: Then why say you don't know? O: (Knitting his brows) I can't seem to think.

E: I want you to remember what you have been saying when you awaken. Do you think you can? O: Yes.

POST-HYPNOTIC STAGE:

E: Do you remember anything? O: Yes. You asked me what went on in the first hypnosis; about the problem you gave me; what I replied to your question, "What did you say?" when I gave the answer to the problem; and something about the Interim Stage. You asked me if I was thinking in the Interim Stage that you told me I wouldn't remember; and you asked me where the things went to which you told me I'd forget, and if I thought in the Interim Stage of the things you'd said I'd forget (all statements are correct to this point); or whether they didn't occur to me at all (not correct). You asked me the number of the page of the book; the first proper name you spoke; how I gave the answer (these all correct).

E: Do you know what those are now? O: Yes (giving them correctly).

E: How did you give the answer? O: I spoke it automatically (correct).

E: Do you remember speaking it? O: No, only my answer to your questions about it.

E: Do you remember the events of the Interim Stage? O: (Much perplexed) You asked me, at the end, if I recalled any of the names of the fables I'd passed over in looking through the book (correct). Nothing else.

E: Do you remember reading a book? O: Yes (but adds); I don't know whether I remember the act itself or what I told you afterwards.

E: You don't know, then, what automatic speaking feels like? O: No.

E: Do you remember telling me you hadn't said anything? O: I don't think I do.

Tests of suggestibility are negative. O cannot remember events of Hyp. 1, but does remember telling about them in Hyp. 2.

Probative character of this experiment: O performs the somewhat complex act of selecting data and computing with them according to a plan known independently to E; and *immediately afterward* is unaware that he has done so; recalling it, however, later, without access to any source of information outside himself. The data available at the time the act was being performed do not, however, necessitate the interpretation that there was more than one conscious state in operation; but O's own later introspection (of course not objectively verifiable), given in Hyp. 2, implies,

if true, the simultaneous existence of two dissociated groups of mental states, *i.e.*, co-consciousness.

Associative relations among the several stages and subgroups: By aid of a suggestion, Hyp. 1 is dissociated from (not "known" to) the dominant group in Int. but not from the (hypothetical) problem group. It is associated with Hyp. 2 but, again, dissociated from Post-hyp. The dissociated groups (if there be two) of Int. are reunited in Hyp. 2; but in Post-hyp. the (hypothetical) problem group has entirely disappeared and the dominant group very nearly. Hyp. 2, with the aid of a suggestion to that effect, is associated with Post-hyp.

Comments: (1) The actual process of the problem solving is, again, a puzzle. It leaves no traces available for introspection; the results alone are registered, and in the visual field. (2) If one accept co-consciousness as demonstrated in this experiment, then it has also shown that vocal-kinaesthetic—and possibly vocal-kinaesthetic-auditory—sensations may, like the touch-kinaesthetic, be split off to join the problem group. If co-consciousness be not accepted as the legitimate interpretation of the data, we must speak merely of a systematized physiological disconnection.

PART IV

CHECK EXPERIMENTS MOSTLY WITHOUT HYPNOSIS

Section 1. To Test Ability to Perform Wittingly Discrepant Functions Together.

X. Without Hypnosis—Exp. 1–6.

EXPERIMENT X1.

Jan. 24, 1920.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. To test ability without hypnosis to perform two very different tasks together, as a check upon results obtained in hypnosis.

Test I. Directions to O: Add mentally 61, 28, 49.

Results (in about 13 seconds): "It's a hundred and thirty—something. I've forgotten the last column over" (meaning units column). O could visualize the three numbers, set down as for addition. He added the right-hand column. Then, on adding the other, he found that he had forgotten the units figure of the sum and also the original numbers. He gave up in about 30 seconds.

Test II. Directions to O: Write a series of numbers beginning with 7 and adding 7 to each preceding number; and at the same time name orally the states of the Union. (The writing hand in this and the following experiments was, of course, concealed from O's vision.)

Results: O wrote twenty-one numbers, in which the only errors were that the fourth was a repetition of the third, and the sixth of the fifth. Meanwhile he was giving the states as directed. In comment O stated after writing some time that he had never learned 7's beyond 84; that he thought he had written up to hundreds (actually 133); that at the outset the first two or three numbers were confused, but afterward, the two tasks were carried on together up to 84, the writing being mechanical. After 84 he had to *think* of both along at the same time.

Test III. Directions to O: Repeat aloud as many stanzas as possible of America, while writing the Rime of the Ancient Mariner, Pt. 2 (which O said he knew).

Results: The first stanza of Part 2 was written with the following error in the third line: "Still hid in mist" was given as "Still in mist in mist." Meanwhile, he was repeating several stanzas of America as directed.

O commented on the experience as follows: America was not known very well. The experience was not at all like automatic writing; then he had not been aware of writing; now he was fully aware. He felt himself trying to do both tasks at the same time. He could think at times of America to the exclusion of the Rime, while still writing, and yet afterward he knew how far he had gone in writing. Again, when he stopped to recall America he knew where in that poem he had paused.

O needed considerable prompting after the first stanza of America. When unable to go on in oral work he would stop writing.

Conclusions: The character of the work done here does not seem to be very different objectively from that of the Interim Stage in Exp. 1; but the performances in the two cases *feel* to O very different. In the present experiment he *feels* interference and alternation of tasks; in the former he gives no indication of such feeling. Here, then, is an important difference between the two states.

Criticism: Are the tasks assigned him like, in essentials, those assigned in the original experiments, that the present may be a check on the former? The essential seems to be that the check task should be no more difficult than the original. The proper judge is, presumably, the person on whom the check is to be made—he to try both without hypnosis. It is of course not possible that the identical task should be given for both check and original, and in default of a standardized series of tasks equated in difficulty the experimenter must take a chance. Here, however, is a valid adverse criticism.

How serious is this criticism? This may be gauged by considering what this check may be expected, when satisfactory, to show, that is, that hypnosis introduces some factor essential to the successful performance of several divergent tasks together. It would not, however, form any link in the proof as to whether, in the experiment thus checked, co-conscious states had actually been developed. Hence were we to discover, as a result of the ideally perfect check experiment, that hypnosis is not necessary to the simultaneous performance of highly complicated tasks, the question of fact would not thereby be touched, as to whether the performance in hypnosis had really involved co-consciousness. This conclusion, rather, would seem to follow, that hypnosis not essential to successful performance, was essential to the development of co-consciousness.

EXPERIMENT X2.

Jan. 24, 1920.

O: J. L. B. E: C. T. B. R: G. E. H.

A. *Purpose.* As in Exp. X1, a check upon results in hypnosis.

Test I. Directions to O: Write your name in full and at the same time repeat aloud the first stanza of America. (After this was done the first

stanza of Bowdoin Beata was substituted for America. The tasks here and in II and III below were chosen because familiar to O.)

In the performance of this task O wrote, at first in an irregular, unformed fashion, which, however, improved a little as he went along, the following: *Josephly* (Next come n and w, merged with each other.) *o o* (Writing here runs off the paper.) | *Badjer jer* | *Joseph Lynwood Badger.*

Record does not show how well O performed the vocal task.

Test II. O was told to write the first stanza of America while repeating the states of the Union. He produced the following writing:

My country tis of thee | sweet.—

Forgetting after he had repeated a few states, how far he had written, he gave the task up.

Test III. O was told to write the table of 5's, and, at the same time, repeat the states of the Union. He wrote the following:

5 10 15 20 25 30 35 40 50 | 555 55 60 70 75 80 85 90 95, 10 | 105, 1005 110 120, 125, 130 130, 140

O commented on this experience as follows: He executed the task by connecting the name of a state with a number. He started the process by taking a group of numbers, 5—10—15, etc., and, while holding this in mind, repeated the names of states. Sometimes at the end of such a series, he forgot the numbers. He also repeated numbers. After he had gone through this group, he alternated numbers and states; they seemed to be going on together; but the states took the greater effort. Although not thinking of the numbers, he knew, after writing them, that they were correct.

Comments: On the same day an inconclusive experiment was made on the development of co-consciousness. This is not elsewhere set forth in the present report. In it automatic writing of a largely illegible sort was produced, of which, such as it was, O declared that he was unaware at the time and that he could recall nothing of its content. This fact is here recorded because of its contrast with the results of the present check experiments.

B. Purpose: To test O's ability to perform outside hypnosis simple problems of the sort done by him in hypnosis.

Method and results: O was told to add mentally 36, 27, 29. After a pause he said " one hundred and—I have forgotten what the number was—the second number." This in 15 seconds. Describing this experience, O said that he tried to add the first two numbers while they were being given; he had partly succeeded when the third was given; whereupon he lost the second number.

Comments on these check experiments: The general picture here given, in contrast with those of this same observer in hypnosis, is one of less efficiency and greater felt effort (see Exp. 11).

The record is, to be sure, regrettably incomplete; and the same criticism as in Check Exp. 1 arises here: Are the tasks assigned in hypnosis comparable to those assigned outside?

EXPERIMENT X3.

Jan. 31, 1920.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. The same as in Exp. X1.

Method and Results. O was seated at a table with his right hand behind a screen, and was told to discuss woman suffrage while, at the same time, writing an account of the day's doings. He wrote as follows:

I slept until 11.30 this morning | Had lunch 12 this | noon. This afternoon | I went down on the | on the mail at 2.30 reat (?) (read?) | *3.00 P.M. Then | I want mone* (more?) *than*

Vocally O gave at the same time a general discussion without much hesitation. Being told to give arguments against woman suffrage, he complained of not being able to do two things at once. He made a great effort, breathing hard. This, he said, was harder than the Ancient Mariner (referring to a former check experiment). While that was more or less mechanical, he felt that now he was doing two things at the same time. The end of the writing seems to show considerable interference.

Conclusions: (1) Outside hypnosis O is not able to perform complicated activities with such ease, especially in the matter of vocal execution, as in the original series of experiments. He appears much more hampered. (2) Success so far as attained seems to involve no co-consciousness.

Criticism: As in Check Exp. 1.

EXPERIMENT X4.

April 15, 1920, 2:40 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. As in Exp. X1.

Method. With his hand concealed, O was told to write from memory a poem "Gargoyles" by Amy Lowell, chosen as one he knew well by heart. At the same time he was to read aloud from a volume of Æsop's Fables.

Results. The following writing was produced: *Gargoyles a comedy of opposition | Thimble rig on a village | green | Snake charmers under a | bblue tent | Winding drugged sausage | bellies thru thin arms.*

The script was more regular and more like O's ordinary style than were his automatic productions. The content shows an entirely successful reproduction, even to capitals at the beginning of each line of the original text.

While writing O was reading aloud in a manner very different from his usual one. He read very jerkily, with slight pauses every two or three words; and his voice was monotonous. On finishing, he could remember nothing of what he had read, not even the characters in the fable. Describ-

ing the experience, he said that he had been able to write "by reading and thinking in pauses; his attention alternated but thought of writing altogether. Said task was made easy by neglecting entirely the reading and pausing frequently." (This description, quoted from the record, leaves something to be desired in the way of clearness in details, though its general drift does not seem doubtful.)

Conclusion: In his normal state, O's ability to perform two widely divergent tasks at the same time is far inferior to what he can do outside hypnosis with the aid of a previous hypnotic suggestion.

Have we the right to say that there is co-consciousness involved? There was a writing consciousness, as shown by O's own later account of that task, but that account shows the possibility of occasional lapses in this particular mind-group. The eye-voice-group was engaged in a task that was also conscious, but seemingly devoid of its usual felt meaning, again, with apparent lapses in the task. The vividness of the writing-group was, in O's feeling, almost always much greater than was that of the eye-voice-group; and proven so by O's total failure to recall the contents of the reading. There was certainly no complete dissociation between the two groups. The above mentioned "lapses" may, of course, possibly, have been occasional instances of co-conscious dissociation, but seem scarcely to require that interpretation any more than does the movement of a sleeper's limbs in response to certain stimuli. In the present experiment our usual criterion does not require us to assert the presence of consciousness. Alternation of vividness between the tasks, with an occasional entire lapse of consciousness for one, if not for the other also in alternation, seems to be all that we can properly assert on this point.

Comments: How comparable is the double task in this check experiment with the double task in the probative experiments? Analysis of the two cases seems to show that in the check we have the easier task (reading and writing-from-memory versus conversation and problem-solution); yet the apparently easier is performed with much greater apparent difficulty.

EXPERIMENT X5.

April 28, 1921, 2:20 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. As in Exp. X1.

Directions to O: I shall give you a piece of prose to read. If there be more than 19 lines in the selection, add the actual number to 52; if less, subtract the actual number from 52. Keep on reading the next selection, giving the answer as soon as possible.

O was handed a book of Æsop's Fables open to a selection having 20 lines. He proceeded to read in a constrained style, quite other than usual in either normal state or interim stage, conveying little connected sense of the meaning to an auditor. E found difficulty in understanding, not because the words were not clear, but because they were not grouped significantly. He gave 73 as the answer to the problem, the correct answer being 72. He stated later, however, that there were 21 lines, and, on that erroneous count, his computation was correct.

E: What do you recall of what you have read? O: Only something about a bramble and a fir tree (in the second selection).

E: What about the first selection? O: Nothing.

E: How did you perform the problem? O: By counting lines without thinking of the reading and doing problem while reading the second selection.

E: Can you compare this experience with your experience at the writing table, as you reported it on April 26? O: Not the same sort of experience at all.

E: How is that? O: In this case the two processes were alternate; in the other the writing did not conflict with what I was saying.

E: Do you remember the former experience clearly? O: Not very. As in so many of these cases, I remember telling about it but not the actual process. (O did tell about it. See experiment of April 26.)

E: Do you recall anything else about it? O: My writing didn't interfere with my talking.

E: Do you feel chiefly identified with the writing or the talking part? O: With the talking part. (Contradicts a statement made in hypnosis in another experiment June 10, 1921.) I remember that a little while. I do not remember at this moment the writing at all.

Conclusion: O's ability to carry on together, in his ordinary unified state, two complicated functions is far inferior to this ability in his dissociated condition in the Interim Stage, *i.e.,* outside hypnosis, but with the aid of a previous hypnotic suggestion.

Comments: (1) The results indicate that the problem solving, not the reading, was the vivid part of O's experience, as shown by the mode of vocalizing and the memory for the contents of the selection. (2) O felt a marked difference between his present experience and the Interim Stage; and that, in the present case in contrast with the former, the functions were not simultaneous. (3) He felt that the events of the Interim Stage were less fully

represented by direct recall than was what he had said about them afterward. (4) O felt himself identified with the voice-group rather than the hand-group—contrary to his feelings in the experiment of June 10, 1921.

EXPERIMENT X6.

May 10, 1921, 3:00 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

Purpose. As in Exp. X1.

Directions to O: I am going to give you a problem to solve. Please read aloud the fable that I am about to give you. If there are more than 17 lines in it, subtract the correct number from 79; if fewer than 17 lines in it, divide 79 by the correct number.

The fable contained 20 lines; the correct answer was 59.

Directly after O had finished reading he said "65—61, I mean"; then, still later, "65 was right" (all incorrect).

E: What can you recall from your reading? O: I have forgotten the name of it. All I can remember is that it had something to do with an animal that was besmirching a statue; and that a bird said it would do no good (both correct); but I have forgotten why. I was busy counting lines. The part I do remember was where I got interested in the story and lost track of the lines. I had to fish around afterwards to remember the number. I was trying to count by tabulating, *i.e.*, adding in my mind one more after reading the end of the line; by visualizing the sum at the end of each line in the margin. When interested in the story I lost track of counting; when counting I lost track of the story.

E: What do you mean by "fishing"? O: Trying to recall the total already counted. When I turned the page, I saw at a glance how many lines were left. So I spent the time subtracting while reading the end of the story. There were 13, 14 or 15 lines (really 20)—I don't remember.

E: Was the operation easy? O: No, extremely difficult. Before receiving the book, I tried to devise some easy method for counting, but without success.

Conclusions: Under the normal conditions of this experiment the two tasks are not felt as being performed simultaneously by separate functions respectively, each of which is equally vivid. They rather alternate in vividness, though perhaps neither quite disappears as such. Whatever be their character, they interfere with each other, as shown by the errors in one and the scanty recall from the other. This is in striking contrast with the findings in the hypnotic experiment, *i.e.*, when the discrepant tasks were performed outside hypnosis but with a previous hypnotic suggestion.

Section 1. Y. In Hypnosis—Exp. 1.

EXPERIMENT Y1.

April 15, 1920, 2:50 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. To study ability to perform two discrepant tasks at the same time, *while in hypnosis,* for comparison with similar performances outside hypnosis, either with a previous suggestion in hypnosis (Exp. A) or without it (Exp. X4–5).

(This experiment followed a similar one performed without hypnosis on the same observer.)

Directions to O: Being hypnotized, O was told to write a stanza of Amy Lowell's "Gargoyles" from "Pictures of the Floating World" (chosen because known verbatim by O), and, at the same time, to read aloud from Æsop's Fables. Passages were selected by E that had not previously been used in these experiments. The writing hand was concealed.

Results. O read rapidly in a low voice without great emphasis. The right hand, at the same time, produced the following:

Tree lights . . . drip cockatoos of c . . col (Pencil runs off paper.) | . . . *Upon broadest shoulds* | . . . *Deread . . . . . to a* | . . . | *silver fish* | *Gluttonous . . . hands . . .* | . . . *apron stroings And . . . re* (Pencil runs off paper.) | *red apple . . . Slide under* | *ice flows and waltz* | *clear thru . . . to the . . . tropics . . . To sit am* (Pencil runs off paper.) | *Cocoanuts and . . . caress* | . . . . |

The original stanza—the second—runs as follows:

"Tree lights
Drip cockatoos of colour
On broadest shoulders,
Dead eyes swim to a silver fish.
Gluttonous hands tear at apron strings,
Reach at the red side of an apple,
Slide under ice-floes,
And waltz clear through to the tropics
To sit among cocoanuts
And caress bulbous negresses
With loquats in their hair."

Most of the dotted parts of the record above are filled in the original script with characters that resemble a series of figure 8's, written in sequence without lifting the pencil, or, occasionally, occurring singly. They are obviously not illegible attempts to write words of the text since they are alike, while the omitted words differ among themselves. Sometimes, moreover, they occur where no word is omitted. They probably indicate some recurrent mental state of another sort, perhaps mere forgetfulness. These same characters occur not infrequently in the earlier automatic writing of this same observer.

E: What are you reading about? O: A goose and a peacock (correct).

E: How many fables did you read? O: Three (correct).

E: What was the goose-and-peacock fable about? O: The goose wanted more than his lot (correct).

E: What was the fable of the mastiff about? O: The mastiff got splashed by the goose (really, slapped angrily with her feathers by a pond-side).

E: What was the meaning of the fable? O: I don't recall.

E: What are you doing with your right hand? O: Writing.
E: What? O: Second stanza of "Gargoyles" (correct).
E: Were you doing both at the same time? O: Yes.
E: Did the tasks alternate? O: No.
E: Did you understand what you were doing? O: Yes.
E: Was it hard to do? O: (hesitates).
E: Why do you hesitate? O: Because sometimes I wanted to say what I was writing and sometimes I wanted to write what I was saying. They tended to intermingle.
E: Are you asleep or awake? O: Neither.
E: What is your state? O: Hypnosis.

O was then wakened and asked to recall what he had been doing. He replied that he could not. He thought there was something to remember but he could not put his mind on it. It seemed to him like the ordinary experience of having a name on the tip of the tongue but not being able to get it.

He was told to put his mind on it. In reply—could remember if he made an effort; recalled walking (presumably between the table and easy chair); other things there but he couldn't utter them.

Being asked whose name was next his own on his class list, he replied correctly (showing that the power to recall was not in general lacking). He was then asked again to tell what he had been doing and assured that he could recall. He replied: "Sitting at the table."

E: Go on. O: Reading a book.
E: What else? O: Writing.

He said that he could recall no more; that it seemed like a dream, differing greatly from usual experience. (This ambiguous statement perhaps means the experience of trying to perform discrepant tasks simultaneously, without hypnosis.) Being asked how they differed, he replied that one was alternate and the other simultaneous. (The record does not state which was which.)

Describing further his recollection, he said that he had a visual image of himself reading and writing; that the book had a red cover and opened nearer the back than the front (both correct); that he recalled the feeling of the pencil, its number and size—No. 6. (This cannot now be verified. In any case O presumably saw the pencil before or after the writing.) He could not recall the reading part and could not hear himself reading (*i.e.,* had no auditory images of it).

Conclusions: The discrepant tasks were carried on with considerable success, as shown by a fair reproduction of the selected text in writing and by the fluent reading. The amount of the latter recalled was, to be sure, slight and not always correct, and fable meaning was not remembered, though O professed to have understood the reading; but E did not press very hard for details while O was in hypnosis. Pressure after hypnosis yielded but little and that insignificant, except for the nature of the two discrepant tasks.

Details of the reading were, according to the record, better recalled than those of writing, but E did not attempt to get more than an identification of the latter during hypnosis.

Without much insistence on E's part, O would have recalled considerably less after hypnosis.

There was found no objective evidence of mutual interference between the tasks; O felt, however, that they did interfere somewhat but did not alternate. There was no evidence for dissociation during the performance of the discrepant functions.

A comparison of these results with those obtained in experiments without hypnosis and after hypnotic suggestion yields the following:

The reading function was best carried on after hypnotic suggestion and worst outside hypnosis.

The writing function was best carried on outside hypnosis and worst after hypnotic suggestion.

In both functions, second best results were yielded in hypnosis.

The ability to recall the events of the complex performance cannot be compared in the three cases as proper tests were not made.

The honors, thus, for the best combined performance of these discrepant functions must go to that carried out in hypnosis, as shown in this present experiment.

Section 2. To Test Ability to Produce Automatic Writing without Hypnosis. Z. Exp. 1–2.

EXPERIMENT Z1.

May 10, 1921, 1:45 P.M.

O: G. E. H. E: C. T. B. R: J. L. B.

Purpose. Automatic writing without hypnosis, sought for comparison.

Method. O was told to sit at the table where automatic writing in hypnosis was usually tested, as the observer knew. He was also told to put his hand behind the screen. There his hand touched the pencil and picked it up. Nothing was said about the object of the experiment. From a volume by J. R. Lowell, "Latest Literary Essays," O was asked to choose the essay that he preferred to have read aloud to him by R. During the reading, E sat somewhat apart where he could watch O without being conspicuous. Occasionally he would shift the paper on which O was writing; occasionally, like O and R, show by some expression an interest in the reading, especially if obliged to shift the paper. He directed the course of the conversation, begun when he was satisfied with the amount of writing done. He did not read the writing by G. E. H. till that conversation was nearly concluded.

When J. L. B. in turn became O on the same afternoon (Experiment Z2) he, of course, knew what had been going on; he had also read what G. E. H. had written; but otherwise the method used with him was that already described.

G. E. H. selected the essay on the Progress of the World, from which R read him four or five pages. At the conclusion of the reading he discussed it, remarking that he was chiefly interested in the statement that modern literature was the most despondent. Lowell maintained that the progress of literature was in the direction of increasing melancholy; whereas, said he, progress consisted in building new things on the ruins of old, it is not a statistical increase. These, said he, were the things that interested him most in the essay. He discussed them intelligently, giving his own views; saying that progress would be determined by a comparison of two periods and the acknowledgment of a standard. O's reaction to the reading showed a grappling with one or two special issues rather than a rehearsal of many details. Meanwhile his right hand produced the following:

portrait of Washington . . . | told by | the | marks on the | paper by the marks on the | paper | on the paper | (Reading stopped here.) *told by marks | on the paper | Portraits of Mme | de | Pompadour . . . | with white and gold dress.*

The content of this writing produced without verbal suggestion as to act or content, repeats the content of automatic writing produced in a former hypnosis, by suggestion, as recorded in Experiment 9 of Part II. It continued during both reading and conversation, and stopped when O's attention was called to tests for anaesthesia.

E: What has been going on while you have been at the table? O: I don't remember doing anything with my hand.

E: How has your right hand entered into your experience? O: I remember picking up pencil but I don't remember doing anything with it.

Earlier he had said: "I don't remember much doing anything with it"; and now, spontaneously, "I didn't think of my right hand until you started touching it."

E: Which hand did I touch first? O: Left.

Really it was the right hand and done while O and E were conversing as indicated above. Directly after touching the right hand some ten times in various places, E asked O to lay his left hand on the table and, closing his eyes, to tell E when he felt a touch. So the replies showed that there was no anesthesia *then,* of either hand. Until, however, his attention was called to this matter of being touched, in the manner just stated, he was, as it appears from the reply last quoted, anesthetic in the writing hand.

E: Have you ever tried to do automatic writing elsewhere than here? O: I am pretty sure I haven't.

E: Either in hypnosis or out? O: I think neither.

E: Do you feel fully awake? O: Yes.

Tests for suggestibility were negative.

E: How does your general feeling compare with that of the interim stage? O: Not like it.

E: Like it at any time during this experiment? O: No.

E: How does it (the present state) differ? O: More awake feeling—aware of what is going on around and thinking of various things. In the interim stage, not aware of what is going on around and not thinking much of anything.

E: How else would you describe the interim stage? O: The combination (*i.e.,* of the foregoing traits) makes a dreamy state. It seems unreal when you look back on it.

E: Do you recall what you thought when you first sat down at the table

this afternoon? O: The screen with my hand behind it made me think I was going to end up by doing some writing.

E: What attitude did you take toward the writing then? O: I didn't take any attitude; I just thought of it.

E: Tell me what you wrote. O: I didn't know I had written till I got a glimpse of the paper just now.

E: Try to recall it. O (After trying for 15 minutes) Said he could recall nothing.

(For conclusions see the end of the following experiment.)

EXPERIMENT Z2.

May 10, 1921, 3:15 P.M.

O: J. L. B. E: C. T. B. R: G. E. H.

This experiment was immediately preceded, on the same O, by another to test his ability to perform two complicated functions at the same time—reading connected prose and solving an unrelated problem—without hypnosis.

The purpose and method are stated in the introduction to Experiment Z1.

After O had selected the essay on Walton from J. R. Lowell's "Latest Literary Essays," R read aloud from it six or seven pages, then, being asked what he could recall, O mentioned the following details: biography in general talked about; Walton's life as a special instance, spent by cool streams; an unacknowledged quotation from Gray's Elegy noted by O; a poem dedicated to Walton by S. P.; two dedications (in different editions) the same except for one word (error); Walton's character known by the age of twenty-two (twenty-six to be correct); the author's discourses on names—Napoleon, others from the Greek—did not interest O; the name Henry occurred often in Walton's family.

This recollection is reasonably full and largely correct.

Meanwhile a test for anaesthesia of the right hand was proceeding in the method indicated in Z1. Suggestibility was negative.

The following writing was produced in a varied, but mostly cramped, style, differing thus from the concealed writing he intentionally produced.

. . . J L. B. by (?) *th marks by the | by the marks. I knew Roosevelt by the marks | J L B. I knew Roosevelt by the marks | Washington | . . . | Washington . . . I knew Roosevelts | picture by th marks by the | marks marks* (Here follows a series mostly of x's) | *marks marks | . . . | marks marks* | (Reading stopped here.) *marks marks marks | marks marks . . . By marks | . . . J* (?) *L B* (with something written on the place of the initials that may be "By") *mark mark | marks marks marks mark marks | m . . . marks marrks President . . . |*

Several cases of imperfect letters, especially m's, occurred in the foregoing, just as happens in writing normally produced. There were several cases of possible "house hieroglyphics." (See record below.) O reverted in choice of subject to material given in the automatic writing of an earlier experiment, just as did G. E. H. Any conclusions to be drawn from the latter's spontaneous reversion cannot be confirmed by the behavior of J. L. B., since he knew what G. E. H. had done.

E: What has been going on since you sat at the table? O: George has been reading; I was listening. My hand, behind the screen picked up the pencil and made marks, pictures, etc. I paid no particular attention to anything beside the reading.

E: Did you feel any touches? O: Yes, on the left hand. You also touched the right hand—the left hand first (last statement incorrect).

E: Is this state like the interim stage? O: No—guess not. I can't remember the interim stage (laughing a little as he speaks). Interim stages seem almost as unreal as hypnosis. Hypnosis seems like sleep, the interim stage like a dream.

E: How does your present state differ from that? O: As far as I can remember, the interim stage is a half-awake state, like waking-up in the morning—half awake and thinking of things. The present state is fully awake. I make an effort to think about things now.

E: Do you recall anything else (*i.e.*, in the way of a distinguishing difference)? O: No.

E: What did you have in mind when you sat down at the table? O: I was wondering what was going to be read.

E: Any attitude toward the experiment to be carried on? O: No, I wasn't thinking about it particularly.

E: Have you ever tried to produce automatic writing elsewhere than here? O: No. I often write my name, though, while talking to someone or while telephoning—hieroglyphics. Often when taking notes, I stop writing to listen to the professor, and when I look down to my notes again, I find that I have written two or three lines that didn't have anything to do with the rest of the sentence. I've noted this half-a-dozen times—this morning in particular. It is often illegible—this morning clear, the words were "from the."

E: Are you aware of having written anything making sense this afternoon? O: No.

E: Aware of doing anything with the pencil? O: Drawing pictures and making marks.

E: What sort of pictures? O: Crosses, geometrical figures and my particular hieroglyphic for a house.

E: Make that hieroglyphic. O: (hesitating) I can't tell—can't see it—don't know where to start (half laughing as he speaks).

E guided O's concealed hand, without touching it, to a vacant place on the paper where O drew the figure.

E: Have you been making them this afternoon? O: I've been starting them but probably didn't finish them.

E: Write your name. (O does this, in a script larger and more irregular than his usual signature, and much larger than the cramped writing automatically produced.)

E: Any difference between this and mark-making? O: Yes. This is an effort.

E: What is required to produce this? O: Effort. I tried to imagine what the paper would look like, to proportion the letters.

E: In what sense field were your images? O: Visual.

E: Please try to recall what you have written (*i.e.*, automatically). O: I didn't know I had written—no place to start with, in remembering.

E: Think of things as near to it as you can. O: Don't remember anything. Might have written "house" because I was drawing a picture of it. (No indication of it in the record.)

E: (Showing O the paper containing the writing) Does that recall the experience to you? O: No. I remember making those three things at the top—that hieroglyphic.

E: What is that first hieroglyphic? Was it meant to be anything? O: No.

Conclusions: (1) Both observers were able to write automatically without the aid of hypnosis, though neither was aware of having developed such a power prior to, or outside the limits of, our experiments. One of them, however, had shown some fragmentary writing automatisms. (2) In both observers, the quality of the writing content was not unlike that produced by the aid of hypnosis. (3) In both, this writing was accompanied by other occupations as diverse and complex as in the hypnotic experiments. (4) The results from both show that automatic writing can be produced when one feels as much awake as usual, and is not suggestible either in the writing hand or elsewhere. (5) The content of the writing was spontaneous and reproduced that of former co-conscious processes (automatic writing). In the case of G. E. H., its selection may have been due to place association; beside this possibility, in the case of J. L. B., is the other, that it might have been suggested by the known content of G. E. H.'s production. (6) It seems, at first, that we have here evidence for the existence of co-consciousness in the normal state. The evidence, however, does not satisfy the canons we have accepted. We may have here no other than a purely physiological process. If, on the other hand, its possibility is elsewhere proven, the same interpretation may properly apply here; and we then have, in our present results, confirmatory evidence. (7) There is, however, no evidence here for continuous and persistent dissociation; conditions prevalent at the time may have caused it. (8) Whatever the process be, whether mental or only physiological, it is in some way dissociated (or just disconnected), as shown by (a) anaesthesia, (b) O's ignorance that he is writing, and (c) his ignorance of its content. This was shown by both observers. (9) The introspective report of the felt difference between the Interim Stage and the mental state during the present experiment is significant in the case of G. E. H. No probative value attaches to the introspection of J. L. B. since he had heard the other's account.

PART V

CONCLUSIONS AND COMMENTS

If the reader has well considered the statement made in connection with each experiment as to its probative value, he will recognize that a general conclusion must take the form of an unnecessary repetition, to the effect that co-consciousness is demonstrated as existing in certain normal persons, in hypnosis; that, therefore, by the canons of proof laid down at the outset, we are justified in abandoning the hypothesis of mere neurone systems functioning disjointly.

The "intelligent" character of the co-conscious processes consisted in obtaining new data, performing simple mathematical problems, interpreting codes and acting accordingly, and in revealing unrecognized bases for choice—all in accordance with plans accepted from the experimenter.

Of the check experiments five out of six show that discrepant functions can be performed at the same time more efficiently in dissociation than in the normal state. The remaining experiment showed no important objective difference in results from those obtained in dissociation, but it did show greater felt difficulty of function. The check experiment performed wholly within hypnosis and without dissociation showed simultaneous performances superior on the whole to all those obtained under other conditions; but this needs a good deal of confirmation.

Finally, the check experiment on automatic writing shows that a good performance can be obtained without the aid of reinforcing hypnotic suggestion. It confirms in this respect the results obtained in Exp. 1, 2, 9, and possibly I.

Some interesting facts about the structure of mind during the state of dissociation have been brought to light. Dissociated, discrepant systems (functions) are dominated by a unifying idea, in part furnished by the hypnotizer, in part a product of the state of hypnosis. This dominant idea determines and maintains the state of dissociation. In this way the efficiency, the fluency, of

the several discrepant systems is sustained, as against their usual interference with each other. There is great variation in the association between Hypnotic Stage 1 and the Interim Stage, on the one hand, and either Hypnotic Stage 2 or the Post-hypnotic Stage, on the other. Where such association occurs, its extent varies considerably. Why the impulse to dissociation—whatever that impulse really is—should so vary in efficiency, and what actual countervailing impulses, if any, are in operation, alike remain a mystery. Of the latter the only ones the experimenter has detected as probably operative in the men on whom he tried, either successfully or unsuccessfully, to obtain results, are timidity, dislike of effort, and dislike of felt confusion among ideas. As to effort, it seems that the reinstatement, even in memory, of the complex functions of the Interim Stage involves difficulties not attaching to the original occurrence, where all operations move on smoothly enough. Functions in hypnosis are felt as effortless by comparison, though the act of recalling in hypnosis is not infrequently accompanied by signs of effort. Such evidence as is available seems to indicate that this effort is due to some opposing impulse, some dislike for the complex dissociated state, which is quite absent (or in turn inhibited?) when that complex state is present. The latter feels confused in retrospect but not when in operation.

Some facts of interest about the state of hypnosis come into view. Verbal suggestions in hypnosis to remember its events on waking are not always necessary to ensure recall, nor at other times are they always sufficient. There is, further, in hypnosis a lack of curiosity, of shifting interest. Events not connected with the dominant idea are noticed but unnoted—are perhaps weakly vivid. There is dulness of expression, even when eyes are open, that contrasts markedly with the alert glance occurring at once upon cessation of hypnosis. Is it like the state when the sleepy person has abandoned himself fully to sleep; the state when the eyelids are closed, and the delicious feeling of eyes rolled up and out has come on; and yet thinking may be very clear, and visual experiences perceptual in distinctness may be developed? The observers say sometimes that they are awake,

sometimes that they are asleep, sometimes that they are in hypnosis; that they seem floating in space without sense of direction. They feel comfortable—more so than in the Interim Stage; they "don't care." They have delusions of bodily control, which change to illusions in the face of the difficulties they meet. "I feel that I could if I wanted to, but I know I can't."

The experiments in automatic speech suggest a further line of inquiry that may be of value. The amount of such speech was indeed very small, yet it was strictly all that the conditions of the experiment provided room for. No attempt was made to determine how extensive an automatism might in this field be developed as a simultaneous dissociated function. The experiments, so far as they went, were an attempt to discover whether the voice was as available as the hand for the medium of expression of the subdominant group, that is to say, of the group engaged in expressing the dissociated idea, as against the group engaged in adapting to the chance occurrences in the environment. The conditions of the experiments were not such as to prove the obtained speech to be a simultaneous conscious function, rather than purely physiological. More extended speech would be necessary, that one might be sure by the expressions of the dominant group, in turn, that it had not momentarily yielded the field; sure also by the specific character of the speech that it was being determined, as it went on, by assignable psychic activities. The present experimenter regrets that he failed at the critical time to penetrate into the meaning of his opportunity and the full demands of the problem.

The results that were obtained showed the fluctuating content of mental systems, the preying of one system on another, spontaneously occurring through instinctive impulses, whose force was coöperative or competitive with that of the dominant dissociating idea. This also may be worth further inquiry.

The superior efficiency with which simultaneous tasks can be carried on by the aid of dissociation leads one to mention a possible disadvantage. It is a loss of spontaneity in the scope of pertinent ideas available for a given task. This spontaneity is limited by the dominant idea, which does not itself yield—or yield

readily—to other ideas of spontaneous origin. The dissociated groups may not be able to "think" as widely each about its task as the normally integrated mind. The importance of this limitation depends upon the amplitude of range provided in the dissociating idea. Only experiments yet to be made can tell us about this. One must also note that the "thinking" of men under every-day circumstances is in its turn subject to its own group of strictly limiting conditions. No one can "think about anything he wants to"; there are other essential determinants beside desire. A little reflection on the hampered, jerky processes of one's deliberate thought is enough for conviction here.

VOL. XXXIV
No. 3

PSYCHOLOGICAL REVIEW PUBLICATIONS

WHOLE NO. 156
1924

Psychological Monographs

EDITED BY

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STUDIES IN PSYCHOLOGY

FROM

THE JESUP PSYCHOLOGICAL LABORATORY

Relation of the Rate of Response to Intelligence

BY

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PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.
AND ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.); Leipzig (Hospital St., 10); Paris (76, rue de Rennes)

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V. 34 3

ACKNOWLEDGMENTS

The writer wishes to acknowledge his indebtedness to those whose aid has made this study possible. He is especially indebted to Dr. Joseph Peterson of George Peabody College for Teachers for his encouragement and criticisms during the progress of the work. He is also indebted to Dr. S. C. Garrison for the privilege of using in the study certain data which the latter had collected.

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INTRODUCTION

Recent years have witnessed an increasingly wide use of tests both as measures of intelligence and as measures of abilities in various special lines. The development of many of these tests has apparently proceeded upon the assumption that test scores made under definite time limits are not seriously influenced by that fact. This is especially true in the field of intelligence tests. A brief survey of the group tests of intelligence reveals the fact that among the scores of such tests now on the market one rarely finds a test which does not employ definite time limits within which the individual tested must give whatever evidence he can of his mental capacity.

This tendency to extreme simplification of mental testing through increased emphasis upon the rate of response, that is, through taking as a measure of intelligence the number of exercises an individual can do correctly in a definite length of time, is most explicitly brought out in a recent revision of the Binet-Simon scale (13).

The author says that "The large number of new tests introduced that score directly in terms of time and error will indicate the importance given this matter" (13, p. 22). Of the 80 tests used in ages 6 to 15 inclusive, 53, or 65 per cent, are timed tests. There are 13 tests that are credited in more than one-year level on the basis of the time and error scores. Some of these are credited in as many as six different year levels, according to the time and error scores made. The tests for age levels of 12 to 15 inclusive are made up entirely of time-error tests.

For example, an opposites test of 20 words is given and each response timed. The errors and the average time are added. If the sum equals 5.3 or less the child is credited with 13 years; if 4.2 or less, he is credited with 14 years; and if 3.3, with 15 years. Similarly, a column of mixed fundamentals in integers is

scored on a time and error basis and the various results regarded as indicative of various levels of intelligence.

The fact that emphasis upon time limit has grown out of an attempt so to simplify test administration that the possibility of errors at the hands of the untrained may be reduced to the minimum does not mitigate the seriousness of the consequences, if it should be found that rate of response or speed of work may in many cases be largely independent of intelligence. And oddly enough the literature of mental testing does not reveal experimental studies that even approximately settle the matter. The Army experiment, the only serious attempt, made no claims of finality, though it showed that within limits there was a correlation between speed and intelligence as measured by the Alpha test.

The absence of an adequate empirical basis for postulating any particular degree of relationship between speed of responding to intelligence test material and quality of responses or of some acceptable criterion of intelligence, makes the question of practical as well as of theoretical importance. It is the purpose of this study to investigate the problem, and to give some mathematical statement of the relation existing between intelligence and speed of response.

I. HISTORICAL

Investigations to determine the significance of rate, or speed, of human reactions have included three main lines of research: sensory and perceptual discrimination, learning and memory, and general intelligence. Each of these, in turn, has presented more specific problems. In sensory and perceptual discrimination the rate of presenting materials to be discriminated has been studied in relation to accuracy of discrimination. Learning and memory involve such questions as relation of rate of learning to accuracy of reproduction, relation of rate of learning to general capacity for learning, relation of rate of reproduction or recitation to accuracy, and relation of rate of reproduction to general capacity for learning.

Finally, the problem of general intelligence has been considered from various angles. The relation of rate of acquisition of reaction possibilities to general intelligence is fundamental. The concept of mental age embodies the notion of a close relation between the two. A second angle to this question involves the question of rate of response to general intelligence. Here rate of response is independent of rate of acquisition. A closely related and very similar problem embraces the question of rate and comprehension in reading. A third angle relates to the connection between speed of learning and intelligence.

In 1909 Burt (5) found the correlations between speed in various performances and intelligence in the case of 30 elementary school children. Intelligence with card sorting gave .52 ± .09, and with alphabet sorting .61 ± .08. Intelligence was estimated by the headmaster, who, when in doubt as to the relative position of two or three boys, employed as his test question, " Which boy is the quickest at seeing the point of anything? "

For the purpose of selecting good measures of intelligence Wyatt, 1913,(20) gave to 34 children tests ranging from marking the letters *e* - *r* to interpreting fables. Wyatt used an arbi-

trary system of penalizing errors, and obtained correlations of .40 ± .097 and .45 ± .09 between *e - r* and *a - n - o - s* tests, respectively, and intelligence.

Brown, 1910,(3) found the number of letters, *e - r* and *a - n - o - s*, that 11- and 12-year-old boys and girls could mark in five minutes. The tests were repeated at the end of two weeks. General intelligence was determined from the independent rating of two teachers, which ratings correlated .90.

The correlations for the measures indicated were:

	39 girls		40 boys	
	r.	P.E.	r.	P.E.
e-r with intelligence	.00	...	.28	.10
a-n-o-s with intelligence	.13	.11	.10	.11
a-n-o-s with school marks	.27	.10	.17	.10
e-r with school marks	.00	...	.30	.10
school marks with intelligence	.64	.09	.78	.06
e-r with *a-n-o-s*	.80	.06	.82	.05

Judd (11) arranged the results of 1,831 children in reading in Cleveland so as to show the relation of speed to quality. Each child was put in one of three groups, " rapid " or highest 25 per cent, " slow " or lowest 25 per cent, or " medium " or middle 50 per cent, according to his rate score. A similar division was made to include " good," " medium," and " poor " quality. The results show these children divided as follows in rate and quality:

	Judd		King	
Rapid speed and good quality	10	per cent	8.6	per cent
Medium speed and good quality	11	"	10.7	"
Slow speed and good quality	4	"	5.4	"
Rapid speed and medium quality	12	"	10.7	"
Medium speed and medium quality	26	"	25.6	"
Slow speed and medium quality	12	"	14.0	"
Rapid speed and poor quality	4	"	5.4	"
Medium speed and poor quality	12	"	14.0	"
Slow speed and poor quality	9	"	5.4	"

Judd says of these findings: " These figures seem to emphasize the fact that good readers are usually not slow and poor readers are usually not fast. . . . For the purpose of this survey the general fact that high rate and good quality are commonly related, and that low rate and poor quality are commonly related is of great importance " (11, pp. 154, 155).

Since a contingency coefficient of only .22 by Yule's formula

(21, p. 65) is obtained from Dr. Judd's data, it is not clear just how he arrived at such conclusions.

In the same year King (12) published results of 93 university students in reading. Though his method is different from that used in the Cleveland survey, the results are practically identical. He finds a Pearson *r* of —.07 between rate and comprehension. His method probably placed the slow readers at some advantage over the rapid. He says: "There are all degrees of difference among individuals in rate of reading. These differences are doubtless due to both innate and acquired factors. Some people react slowly; others move quickly. There is no doubt also but that there are varying degrees of comprehension associated with each differing rate of reaction, *i.e.*, the more slowly reacting group includes some who are keen to comprehend and some who are quite dull, with all gradations between; and the quick reactors also include various degrees and types, such as the keen, the dull, the thorough, and the superficial" (12, p. 830).

McCall, in 1916,(14) first raised definitely, so far as the writer has been able to find, the question of the probable desirability of "speed" tests and "power" tests as measures of mental ability. "By 'power test' we mean," he says, "one that contains units sufficiently difficult to discover the maximal ability of the person or persons being measured." Binet-Simon scale and Trabue completion test are cited as examples. It should be added that any time limit in a power test should allow opportunity for all to reach the limit of their abilities.

Eighty-eight boys and girls in the grammar grades were given a series of speed tests by McCall: Cancellation, handwriting, addition, and looking up and copying addresses from a directory; and a series of power tests: Thorndike's Visual Vocabulary, Trabue's Completion, Thorndike's Reading Scale Alpha, arithmetic problems, and Thorndike's Omnibus tests I A and II A. Teachers' ranks and school marks, composite of all tests, and the average of these were used in turn as criteria of mental ability.

As the correlations with each of the three criteria are so nearly the same the average will probably give the best view of the facts. The average correlation of each test with the three criteria

follows: Omnibus, .80; completion, .78; teachers' rank, .75; school marks, .73; reading, .67; arithmetic, .61; visual vocabulary, .60; copying addresses, .39; addition, .27; handwriting, .12; Cancelling A's, S's, 2's, and 3's, —.03, —.06, —.23, and —.23, respectively; and age, —.25. The average correlation of the so-called "power tests" from this group is .69 and for the "speed tests," .03. The average of reliability coefficients for these two groups is .52 for the power tests and .95 for the speed tests, and for school marks, teachers' ranks, and composite, .88.

McCall says that "some of the factors which make for high reliability coefficients are: that the function tested be narrow; that the time spent in testing be long; that the test material and experimental technique for the two tests be identical; and that there be no large variation in the conditions of the subjects."

"To sum up the entire discussion," he says, "the power tests give a much higher correlation with mental ability than do the speed tests; and this is true whether average scores or improvement is used as the measure of the speed tests" (14, p. 52).

Anderson presents data (1) showing the average rate of mental association for various groups in responding to words presented. Fifteen eight-year-olds averaged 2.6 seconds with quartile deviation of .8. Twenty-five ten-year-olds averaged 2.3 ± .7, twelve-year-olds, 1.7 ± .4; fourteen-year-olds, 1.6 ± .6; and adults, 1.5 ± .3. While he thinks the type of answer given has some relation to intelligence, he found no correlation between speed of association and intelligence.

Terman (18) found a correlation of .535 between total words named in three minutes and M. A., and .52 between total words named in one minute and M. A. The correlation of the first and last minute was .58.

Terman and his students examined 818 individuals with Stanford-Binet and the Army Alpha test and found correlations which averaged .78, ranging from .58 to .87. The groups included were heterogeneous. No attempt, however, was made to eliminate the age factor (15, p. 332).

Gates (8) studied the rate of reading in its relation to comprehension of what was read, and to general intelligence. He used

the composite of several tests in rate, comprehension, and group intelligence measures, and found the following correlations:

	r	S. D.
Stanford M. A. with Rate	.31	.30
Stanford M. A. with Comprehension	.34	.24
Stanford M. A. with Directions	.35	.20
Group Intelligence with Rate	.64	.17
Group Intelligence with Comprehension	.69	.10
Group Intelligence with Directions	.61	.17
Rate with Directions	.79	.14
Rate with Comprehension	.84	.08
Directions with Comprehension	.78	.14

In the interpretation of these correlations it is well to keep in mind that the reading comprehension tests were in some cases timed tests. These tests were those of Brown, of Courtis, of Monroe, of Thorndike-McCall, and the Directions test. Of these the Courtis, Monroe, and Directions tests are definitely timed, while the Brown and Thorndike-McCall allow ample time for a child to give evidence of what he has comprehended. We should expect the rate element to enter into the reading comprehension score to a considerable degree. The correlations tend to show this to be the case.

Concerning the reading rate and comprehension correlations Gates says: "The correlations with the composite of group intelligence tests is higher than with the Stanford-Binet and those are about as high in the lower as in the higher grades. Both of these facts might be explained by the greater demands of the group tests on reading, which are rather uniformly stable in the various grades, but this explanation is in no way defensible by our data" (8, p. 459).

Root (16) has recently given us the results of a large number of correlations between group mental tests and the Stanford-Binet and between various group tests themselves. About 600 children were tested. The median of 67 grade correlations between Stanford-Binet and group tests is .66, P.E. .077. The median of 17 grade correlations between group tests is .765, P.E. .05. The correlations obtained when all children are taken together irrespective of grade are .80 and .88, respectively. These last show the influence of age upon the correlations. The National

Intelligence test gives a median grade correlation with Binet of .65 with range of .49 to .79.

Root points out that one cause of the variations between the Binet and group tests is probably that "the Binet is largely independent of the element of time; mass tests must of necessity rest on a time basis. We do not know to what extent different subjects are benefited in one case and injured in the other, or *vice versa*" (16, p. 292).

Gates (9) shows the relation of reading ability to intelligence as determined by three types of intelligence measures: Stanford-Binet mental age, verbal group intelligence score, and non-verbal group intelligence score. The correlation of reading ability with Stanford M. A. was .49, M. D. .16; with verbal group test .71, M. D. .06; and with non-verbal group test .20, M. D. .07.

We are by no means justified in saying that the difference between the verbal and non-verbal tests is due to the verbal element. The very fact of a test's non-verbalness means that a different kind of task is to be performed, which, while differing from the verbal in respect to the verbal element, also differs in respect to the nature of the tasks to be performed.

Freeman (6) cites a study in which the correlation between the score on the Burt reasoning test and the time required to complete the test was zero.

Freeman found the correlation between the speed, as determined by the order of finishing, and the quality of performance as measured by two tests on subject matter of class. One hundred fourteen, largely graduate students, were tested with a multiple-answer and a completion test constructed to measure content of mental test course. The correlation between the order of finishing in the two tests was $.50 \pm .05$. The two tests correlated $.55 \pm .047$. Freeman says: "Since the content of the two tests was in part different this indicates again a fair degree of reliability." The correlations between the rate of work as determined by the order of finishing and the quality were $-.13 \pm .07$ and $-.12 \pm .07$, respectively, for the two tests. So he concludes that, "There may be real differences in the quality of work

of which one is capable which are independent of speed of performance" (6, p. 88).

Gates, 1922,(10) found an average correlation of .55 between Stanford M. A. and the mean of several group tests. The average of the correlation between M. A. and the different group tests was .46, S. D. 15. The National Intelligence tests, forms A and B combined, with Stanford M. A., gave .46, .52, and .58 for grades four, five, and six.

Garrison (7) obtained similar results with 158 cases in grades four to eight with the Otis test. The average of the correlations between Stanford Revision and Otis was .48, with a range of .23 to .57.

So far as the writer has found, only two studies have been made directly upon the relation of speed and quality in intelligence tests now in general use.

The first of these was in connection with the standardization of the Army Alpha scale (15). Five hundred ten recruits were given the test. When time was called on a test the recruits were asked to draw a line to show how far they had gone. They were then instructed to go on with the same test, but not to go back of the line to correct anything, until time was again called. The time allowed the second part was the same as for the first. Each test was given in the same manner. In this way it was possible to determine what a person's score was for the two time limits, *i.e.,* single time and double time. The purpose of this comparison was to determine whether there was any marked change in relative position under double time as compared with single time. The correlation obtained between single and double time scores was .965. This means, of course, that there is but little change in relative position due to doubling the time.

More instructive, probably, than the coefficient of correlation is the analysis of the data to show the per cent of individuals at each level of the various tests in single time who gained in double time. The conclusions from this analysis are given as follows: "We might say, therefore, in the case of these tests, that they are neither principally 'speed' tests nor 'power' tests, but tend to show the characteristics of a 'power' test more at the

low levels than they do at the high levels. The high frequencies of persons gaining at the upper levels (often 100 per cent) indicate that for the people making high scores in single time the 'speed' element is predominant. In the middle and lower ranges the 'power' element is more important. Many persons do not gain in the additional time. It can hardly be said, however, that at these levels the 'power' factor is ever so important as is 'speed'" (15, p. 419).

The second study directly concerned with the speed-quality relationship in intelligence tests was recently reported (17) by Ruch and Koerth. From a number of freshmen who had previously been ranked on the basis of Thorndike's, Morgan's, and the Iowa Comprehension tests combined, were selected the lowest and highest deciles, 70 in the low group and 52 in the high. These were given the Army Alpha Form 7 in such a manner as to reveal their scores for single, double, and unlimited time. A correlation of .966 was obtained between single and double time and .945 between single and unlimited. This leads the writers to say that, "The agreements between the correlation of single and double time with that reported in the Army figures is striking."

Apparently these writers have overlooked the fact that correlations are much affected by the degree of heterogeneity of the subjects tested. They have obtained these correlations from highly selected data, *i.e.*, from the extreme deciles of the original distribution. In such a selection they leave out of account those deciles where variation is least or where differences are smallest, *i.e.*, those nearer the central tendency. A formula for evaluating a coefficient of correlation obtained under such conditions has not come to the notice of the writer. But the fallacy of the correlations presented by these writers may be shown to some degree by the simple process of correlating the measures for the two deciles separately. That is, we may take the distribution given by Ruch and Koerth for the low group in single and double time and on the basis of that find the degree of correlation existing when the high group is left out of account. Then we may do the same for the high group with the low group left out. This gives us a correlation of .86 between single and double time for the low

group and of .71 for the high groups. And instead of the one correlation of .945 between single and unlimited time, according to Ruch and Koerth, we get .76 for the low group and .65 for the high when each group is taken separately.

Even the coefficients resulting from correlating the deciles separately are much too high, for we are dealing in such cases with the extremes where differences are greatest. If, for example, we take a probability curve of 3.0 sigma we find that either extreme decile extends over 1.73 sigma on the base line. The decile about the median, on the other hand, is limited to .25 sigma. This means that the extreme deciles have seven times the range of ability that is found in the middle decile. Hence it is much more difficult to discriminate ability in the middle decile than it is in the extremes. Since errors in ranking tend to lower correlations, it is evident that the middle decile with its greatest susceptibility to error would give the lowest correlation. That being true, it is evident further that the correlations based upon the extreme deciles taken separately would be considerably reduced if the deciles more susceptible to error were included.

Evidence that an obtained correlation may be in excess of the representative correlation is definitely shown in another way. If, for example, we take all of the children of a school system without regard to age or grade placement and measure them with two intelligence tests we get a correlation out of proportion to the relationship which actually exists among children of the same age or grade. Root (16) shows correlations among a large number of tests worked out according to each arrangement. He found the average of the grade correlations between group mental tests and Stanford-Binet to be .66; and between various group mental tests themselves, .76. But when he disregards the grading the correlations are, respectively, .80 and .875. Garrison and Tippett (7) made a similar study of 158 children in grades four to eight, inclusive. They found an average grade correlation between the Otis Advanced Examination and Stanford-Binet of .48. When the five grades were thrown together in a single correlation table the result was a correlation of .75.

This fact of heterogeneity is in some measure responsible,

probably, for the high correlation, .965, found between single and double time in the Army. In 10 of the 13 companies used in the Army study no men had been segregated for the beta examination. The scores for single time ranged from zero to 190.

It is of considerable importance, then, to know the nature of the series between which the correlation is obtained. A high correlation in human traits means much or little, depending upon the homogeneity of the group from which the correlation is obtained.

Summary of Historical Sketch

1. There is a comparatively low correlation between rate of performing simple tasks and intelligence. The correlations range from .00 (Brown) to .61 (Burt). Most of these fall around .30 to .40 (Wyatt, Brown, McCall).

2. There is a high correlation between rates of performing different simple tasks. Brown gets .80 to .82 and Gates .95.

3. Individuals show considerable differences in rate of response to words presented (Anderson).

4. Group tests and Binet-Simon tests give correlations averaging about .55 to .65 (Root, Gates, Garrison).

5. In all cases linguistic tests give higher correlations with intelligence than do non-linguistic (Gates).

6. The Army experiment and the Ruch and Koerth study do not give sufficient evidence of the closeness of the relation assumed in timed tests between rate of response and intelligence.

II. PROBLEM

A survey of the literature on mental testing reveals the fact that while the time factor in human reactions has been worked at from many points of view, its relation to general capacity is by no means clear. Are we justified, for example, in assuming that the amount a person can do in a definite length of time is the best measure of his ultimate learning capacity? Are we yet prepared to say that the number of items, such as are found in group tests, correctly responded to in a specified time, is the best measure of a person's mental capacity? Or, to put it in another way, do the results of studies demonstrate a sufficient uniformity in rate of work among people that its influence upon the measure of their mental power may be neglected? Is there even an approximately perfect correlation between profoundness or sagacity and speed?

The purpose of this study is to investigate the relation of rate of response to general intelligence. We shall attempt to give at least a partial answer to such questions as: To what extent is an individual's rate of response constant for different kinds of material responded to? Does rate of response vary with material of different levels of difficulty, and is this difference constant for various individuals? To what extent is intelligence a question of rate of response? Can rate of response in linguistic and non-linguistic materials be weighted with time-limited mental tests so as to improve the correlation with our criterion?

This study differs essentially from the other investigations of this problem in that we are employing separate measures for rate of response and for general intelligence, and a third measure combining the factors measured by the other two. Other investigators have used only a single timed test, under different time limits, and, too, without attempting to isolate the rate factor.

III. EXPERIMENTAL MATERIAL AND PROCEDURE

A. Subjects. This study is based upon the responses of 87 boys and girls of the Peabody Demonstration School to the tests described below. Twenty-nine were in the fifth grade, 30 in the sixth, and 28 in the seventh. The median age and I.Q. were for fifth grade 11.0 and 109, for sixth 12.3 and 109, and for seventh 13.0 and 112, respectively.

The complete distributions of chronological and mental ages by grades are given below:

Distribution of Ages in Years by Grades

Grade	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	Total
5	..	1	1	..	2	9	8	3	4	..	1	..	..	..	29
6	..	..	..	..	3	1	3	5	9	5	3	1	..	..	30
7	..	..	..	..	..	..	2	1	2	11	4	4	3	1	28
Total	..	1	1	..	5	10	13	9	15	16	8	5	3	1	87

Distribution of I. Q.'s by Grades

Grade	70	80	90	100	110	120	130	140	150	160	Total
5	..	3	2	10	10	3	1	..	..	..	29
6	1	4	6	4	8	3	4	..	..	..	30
7	..	..	2	10	11	1	1	2	..	1	28
Total	1	7	10	24	29	7	6	2	..	1	87

Standardized tests are regularly administered in considerable numbers during the year to every grade, so that tests of the kinds used in this investigation are by no means a novelty to those tested. Their reactions to tests are, therefore, probably more representative of their customary modes of doing tasks.

B. Tests and Test Procedure. The general plan of the investigation was to employ three sets of measures, including one set as nearly free from the time factor as possible, one set including both the time factor and difficulty, and a third set as nearly as possible purely speed tests. It was thought best to restrict the speed tests to such material as is commonly found in intelligence tests, so that there might be good reason for assuming that some

of the same mental functions were employed with the three kinds of data.

The tests may be considered under three heads, the criterion, the group mental ability tests, and the rate tests.

A. Criterion. The criterion of intelligence used is the average mental age as determined by the Stanford-Binet. For three years, and in some cases four, the pupils used in this study have been tested annually by the Stanford-Binet scale, except for such as have been here a shorter time than that. Fifty-eight of the 87 have had three or more Stanford-Binet tests. Twenty-four have had one test and five have had two. The tests were given under standard conditions, about half of them by Dr. S. C. Garrison and the other half by graduate students in psychology trained in administering the Stanford-Binet scale.

It is probably safe to say that the Stanford-Binet test is as nearly independent of the time element as any test to be found. In only 17 of the 90 tests composing this scale are subjects limited in response time; and in practically all of these the time limits provide ample time for those who can do the tests. Only in one test, the word-naming test, is the time factor very similar to that in group tests. In none of the tests is there a premium on speed within the limits set. A solution of the code test, for example, in one minute gets no more credit than a solution in five minutes. We may say, therefore, that whatever else this test may measure it does not to any appreciable extent measure speed of response.

B. Group Mental Ability Test. From the point of view of the purpose for which this test was to be used there was no basis for determining its suitability. Probably any of the better group tests of mental ability would have served. The National Intelligence test was, however, especially adapted to the ages we were employing. Form 1, scales A and B, was given and scored according to the standard directions furnished by the authors of the tests. This test was given by a trained examiner under the direction of Dr. Garrison.

C. Rate Tests. The aim was to get material similar to that found in group tests and at the same time easy enough to present a minimum of difficulty to the groups of pupils we were using.

Further, it was desirable that both linguistic and non-linguistic elements appear in these rate tests.

1. Rate tests with linguistic element: To meet this requirement, and another to be mentioned later, the Pressey Intermediate Classification test, for grades 3-6, and the Woodworth-Wells Easy Directions tests were selected. The Pressey test consists of a hundred items to be responded to by the multiple choice method. These hundred items were divided into three parts. The division and time limit for work on each were so determined that no individual could finish. Each part had the same time limit, 100 seconds, and this was constant for each grade, as was the method of giving and scoring the tests. The Pressey directions were followed in the main, with such slight modifications as the above divisions made necessary. Each grade was tested separately as a group.

The Woodworth-Wells easy directions tests are fully described by the authors (19). The following brief statement summarizes the main points: " The conditions which it was sought to meet in the test material are: (1) that the motor responses should be very simple and quickly performed; (2) that the instructions should be very simple, but varied; and (3) that the instructions should be as concise as possible, in order that reading time might not be the determining factor."

The two sheets of this test were given at different times. Each sheet had a time limit of 50 seconds for the 20 items.

2. Rate tests of non-linguistic type: The Kingsbury Primary Group Intelligence Scale, Form A, for grades one to four, and the Pressey Primary Classification, Form A, for grades one to two, were selected for this type of rate test.

The Kingsbury scale presents various forms to be dealt with. Test 1 was omitted because it was not of the time limit kind. Test 2 is an " opposite " test; test 3, " completion," and test 4, " form," and they contain 14, 12, and 12 items, respectively, or a total of 38 points. A time limit of 30 seconds was fixed for each test.

The Pressey scale test 1 did not permit of timing by group method, so it was omitted. The remaining three tests, all of non-

linguistic type, were allowed 50, 50, and 30 seconds, respectively. This gives a total of only two minutes and ten seconds working time for the 75 items in the three tests.

Each grade took all of the rate tests on one day approximately two months after they had taken the group test described under B.

IV. RESULTS

A. Reliability of Measures. The determination of the reliability of the measures employed in this study differ with different measures. In some instances we did not have the data for determining the reliability by self-correlations. We have, therefore, treated each measure separately and by that method which seemed most suited to show its reliability.

1. Reliability of the Criterion. Since there are 58 subjects who have been tested for three successive years, 1920, 1921, and 1922, with the Stanford Revision of the Binet-Simon Scale, the scores of these subjects are taken as a basis for determining the reliability of the criterion. As has already been stated, the average mental age of each subject obtained from all the Stanford measures of that subject is taken as the criterion. The reliability of that criterion can be stated in terms of the probable error[1] for the measures for any one year from the average of all the years.

We have used the I.Q.'s of the 58 subjects in the determination of the amount of deviation. The approximate constancy of the I.Q. makes possible comparisons between different age groups.

We may, then, determine the reliability of the Stanford-Binet measures by finding the P.E. of the deviations of the measures for the three years. This was done for the grades separately and as a whole. The results are shown below as Method I.

Since, however, we are using the average of the measures as a criterion, it is desirable to see just how far the measures for each year deviate from the average, or the criterion. This, also, was determined for the grades separately and as a whole. The results are given below as Method II.

Grade	5	6	7	Total
P.E. by Method I.....	3.11	3.61	3.79	3.56
P.E. by Method II.....	2.26	1.97	2.31	2.17

[1] All P.E.'s used in this study have been derived from S.D.'s.

These results are slightly more consistent than the average of 760 retests by Terman, Garrison, Rugg, and Colloton. They obtained an average difference of 4.5 for the retests, while the above results on the same basis average 4.1.

2. Reliability of the Measures of Speed. Since these tests were not repeated it is impossible to state the reliability in terms of self-correlation. It is possible, however, to give the correlations between those tests which evidently measure closely similar functions. The three divisions of the Pressey Intermediate Classification test, for example, show a marked degree of consistency in intercorrelation, in the light of the fact that the tests consumed only 100 seconds each. The average of the grade correlations is .806, A. D. .058. The two halves of the Woodworth-Wells Directions test were allowed 50 seconds each and give an average grade correlation of .53, A. D. .10.

The Pressey Primary and Kingsbury tests give average grade correlation of .667, A. D. .036. The times for these tests were 130 and 90 seconds, respectively. Brown and Thompson (4) point out that a reliability coefficient lower than 0.6 is useless. The Directions tests do not meet this requirement. However, the two halves of the Directions test when combined give a correlation of .744 with the National.

While these are not high correlations, it should be remembered that the time allowed was short, thus giving less time in which to differentiate the different degrees of ability.

3. Reliability of the Group Test. The reliability of the National Intelligence test was obtained by correlating Scales A and B. Since the two parts measure different functions, the coefficient obtained is less than the true reliability. The correlations between the two forms are .75, .77, and .83 for the fifth, sixth, and seventh grades, respectively, the average being .78.

It is interesting to note also that the average of the nine correlations between the different divisions of the Intermediate Classification test and the National is .756. The Intermediate Classification as a whole with the National gives an average grade correlation of .812, or correlations of .844, .803, and .79 for the fifth, sixth, and seventh grades, respectively.

B. Statistical Treatment. Tables I, II, and III show the data upon which this study is based. At the lower end of each column the median and the P.E. of that column will be found. An examination of these medians and P.E.'s reveals differences which it is important to keep in mind while interpreting the various

TABLE I

Showing Fifth Grade Raw Score

	1				2			3	4	5	6	7	8	9	10
	Intermediate Classification				Directions			To.	Pressey Prim.	Kingsbury	4&5	Nat-In. Test A &B	Binet Average	Binet M. A.	Chronological
Cases	I	II	III	To.	"g"	dot	To.	1&2	To.	To.	To.	Total	I.Q.	Mo.	Ag.Mo
1	2	5	2	9	4	4	8	17	32	12	44	140	95	140	147
2	6	5	2	13	4	4	8	21	23	10	33	139	80	115	144
3	13	9	6	28	7	6	13	41	33	12	45	184	110	141	128
4	17	16	13	46	7	9	16	62	32	11	43		119	156	131
5	8	8	3	19	3	6	9	28	34	17	51	152	98	146	149
6	19	12	13	44	7	12	19	63	33	17	50	220	119	151	127
7	17	13	12	42	8	8	16	58	40	25	65	245	112	147	131
8	20	17	14	51	6	9	15	66	36	17	53	240	101	134	133
9	9	12	9	30	6	7	13	43	27	11	38	199	106	140	132
10	15	5	3	23	7	11	18	41	28	14	42	185	100	132	132
11	11	7	7	25	5	6	11	36	31	15	46	169	109	142	130
12	14	10	10	34	10	6	16	50	37	16	53	193	124	156	126
13	10	9	6	25	4	6	10	35	35	14	49	201	114	154	135
14	13	5	6	24	4	6	10	34	33	19	52	190	111	146	132
15	13	9	7	29	5	8	14	43	33	11	44	195	87	118	136
16	13	9	9	31	7	6	13	44	39	18	57	202	110	145	132
17	17	10	11	38	7	6	13	51	29	11	40	249	131	162	124
18	9	8	6	23	6	9	15	38	29	15	44	210	105	148	141
19	9	7	5	21	6	6	12	33	34	14	48	203	104	132	127
20	12	11	7	30	4	9	13	43	44	22	66	201	108	114	106
21	13	8	9	30	4	7	11	41	41	18	59	211	108	152	141
22	8	5	1	14	4	6	10	24	51	16	67	119	115	170	148
23	12	8	6	26	7	4	11	37	26	11	37	195	128	140	109
24	12	9	9	30	7	8	15	45	36	17	53	185	123	156	127
25	1	2	0	3	3	4	7	10	35	16	51	105	114	146	128
26	13	10	8	31	6	9	15	46	38	22	60	145	109	151	139
27	8	8	9	25	4	5	9	34	31	13	44	173	118	147	125
28	5	4	1	10	4	3	7	17	27	6	33	102	80	129	161
29	14	12	10	36	5	6	11	47	34	16	50	201	106	142	134
Med.	12.5	8.4	7.3	27.0	6.1	6.8	13.1	40.5	33.9	15.7	49.5	193.7	109.5	144.75	133.7
P.E.	3.09	2.24	2.5	7.2	1.11	1.41	2.14	9.16	3.20	2.69	6.01	24.75	8.03	8.80	7.9

tables which follow. For example, it may be that the low correlation between the Stanford-Binet test and the National Intelligence test is due to the small P.E. of the intelligence of the group.

The Pearson Product-Moment Method was used in all correlations.

We have assumed linearity in the calculation of all correlations. All arrays have presented, by inspection, a very close approximation to linearity.

TABLE II

SHOWING SIXTH GRADE RAW SCORES

	1				2			3	4	5	6	7	8	9	10
	Intermediate Classification				Directions			To-tal	Pres-sey Prim-ary	Kings-bury	Total	N.I.T.	B.-S. Av.	B.-S.	C.A.
Cases	I	II	III	To.	"g"	dot	To.	1&2	To.	To.	4&5	A&B	I.Q.	M.A.	Mo.
1	14	13	9	36	6	7	13	49	43	19	62	235	91	134	148
2	28	22	18	68	9	18	27	95	48	18	66	292	125	177	142
3	14	13	12	39	7	9	16	55	34	9	48	233	97	152	157
4	21	12	13	46	17	15	32	78	48	27	75	288	97	142	147
5	16	17	10	43	9	11	20	63	46	19	65	269	116	169	146
6	19	13	8	40	8	9	17	57	44	15	59	192	91	124	136
7	12	8	6	26	5	7	12	38	30	10	40	191	89	133	149
8	30	26	22	78	12	14	26	104	53	23	76	336	134	173	129
9	26	22	16	64	14	14	28	92	46	18	64	287	136	167	123
10	16	14	12	42	8	9	17	59	53	19	72	265	112	160	143
11	13	5	5	23	7	9	16	39	39	17	56	215	104	157	151
12	18	16	13	47	9	10	19	66	47	14	61	314	135	196	145
13	17	10	11	38	7	8	15	53	49	25	74	283	106	160	151
14	10	5	7	22	6	6	12	34	44	19	63	152	86	136	155
15	17	16	11	44	8	9	17	61	41	22	63	298	108	133	123
16	15	16	13	44	9	9	18	62	45	15	60	291	121	180	149
17	15	9	7	31	7	9	16	47	36	13	49	173	82	137	167
18	18	16	13	47	8	7	15	62	45	23	68	267	112	156	139
19	16	12	10	38	8	12	20	58	41	14	55	242	113	159	141
20	14	8	11	33	6	8	14	47	46	8	54	192	78	123	158
21	21	15	10	46	9	11	20	66	43	19	62	276	107	157	147
22	16	17	11	44	8	9	17	61	39	18	57	258	110	171	156
23	17	12	15	44	6	9	15	59	41	18	59	244	99	145	146
24	19	15	14	48	8	9	17	65	46	16	62	327	130	183	141
25	19	17	14	50	13	14	27	77	44	19	63	255	115	155	135
26	14	9	7	30	7	9	16	46	46	17	63	232	81	121	149
27	18	14	13	45	6	9	15	60	41	15	56	289	114	154	135
28	20	16	16	52	10	14	24	76	49	24	73	289	121	184	152
29	17	13	9	39	6	8	14	73	49	15	64	190	98	118	120
30	24	17	15	56	14	9	23	79	57	31	88	278	110	166	151
Med.	17.5	14.5	11.5	44.4	8.43	9.67	17.33	60.66	45.5	18.5	62.9	264.7	110.0	157	145.4
P.E.	3.0	3.13	2.48	1.75	1.87	1.87	3.45	11.1	3.52	3.38	6.25	30.5	9.17	13.5	6.85

The absence of correlation between Stanford-Binet and the National Intelligence test in fifth grade is probably due in part, as has been said, to the homogeneity of the group and in part to the presence of certain special reading difficulties in this grade. The writer has worked with this group in an attempt to diagnose cases of reading difficulty. The most pronounced case is that of number 25. This subject was unable to read a second reader acceptably though his I.Q.'s as determined by four yearly Stanford-Binet measures were 114, 113, 117, and 111 for the respective years. Other cases less marked are numbers 22 and 28.

It is not surprising that the highest correlations are between tests that involve the language factor. And between tests involving such language factors and those which do not, the coefficients do not equal four times their P.E.

TABLE III

SHOWING SEVENTH GRADE RAW SCORES

	1				2			3	4	5	6	7	8	9	
	Intermediate Classification				Directions			Total	Pressey Primary	Kingsbury	Total	National	B. S. Average	M.A.	C
Cases	I	II	III	To.	"g"	dot	To.	1&2	To.		4&5	Total	I.Q.	Mo.	
1	16	12	9	37	8	9	17	54	38	25	63	245	105	158	15
2	22	17	15	54	12	12	24	78	37	14	51	335	140	210	15
3	24	19	13	56	11	15	26	82	46	25	71	273	140	217	15
4	28	22	20	70	13	15	28	98	45	21	66	316	116	176	15
5	16	12	12	40	8	9	17	57	32	20	52	228	99	150	15
6	18	15	12	45	8	11	19	64	38	15	53	298	132	181	13
7	27	19	18	64	14	11	25	89	48	18	66	303	116	175	15
8	21	16	17	54	11	14	25	79	46	26	72	309	117	183	15
9	16	16	10	42	6	11	17	59	41	22	63	247	101	167	16
10	16	12	9	37	5	8	13	50	33	19	52	274	113	184	16
11	17	9	8	34	7	9	16	50	37	11	48	221	113	177	15
12	14	10	8	32	6	7	13	45	21	12	33	257	115	178	15
13	19	18	14	51	10	9	19	70	41	22	63	273	104	174	16
14	13	15	12	40	9	11	20	60	44	19	63	282	111	165	14
15	16	12	14	42	11	9	20	62	28	18	46	296	160	226	14
16	17	12	12	41	9	7	16	57	54	28	82	282	113	170	15
17	18	18	16	52	12	11	23	75	49	23	72	303	101	138	13
18	16	12	12	40	8	11	19	59	52	23	75	245	103	161	15
19	21	19	17	57	14	12	26	83	47	21	68	337	113	191	16
20	20	15	14	49	9	11	20	69	48	28	76	296	104	175	16
21	20	14	10	44	5	12	17	61	49	26	75	255	95	161	16
22	24	21	14	59	13	13	26	85	42	26	68	290	121	214	17
23	17	20	13	50	10	9	19	69	39	20	59	287	102	160	15
24	28	25	19	72	16	15	31	103	43	20	63	371	109	177	16
25	25	22	16	63	14	18	32	95	43	27	70	322	115	171	14
26	18	15	12	45	8	11	19	64	42	20	62	246	107	162	15
27	22	18	16	56	12	14	26	82	50	25	75	288	107	162	15
28	25	22	14	61	14	12	26	87	46	29	75	312	114	175	15
Med.	19.0	16.5	14.0	50.0	10.5	11.6	20.3	68.5	43.5	22.0	65.0	287.5	113.3	175.7	15
P.E	2.82	2.72	2.24	7.12	2.02	1.72	3.39	10.5	4.84	3.17	7.33	23.4	9.34	13.8	

Turning to the correlation table (Table IV), we find that the only significant coefficients are those between tests involving language factors. It is evident also from the partial and multiple correlations that the relation between the National Intelligence test and the Linguistic Rate tests is independent of factors measured by the Stanford-Binet tests. $r_{24} = .80$, and when the Stanford-Binet measures are combined in the best way with the Linguistic Rate tests the coefficient is not materially changed. $r_{2.14} = .81 \pm .04$.

The fact that most of the correlation coefficients fail to meet the requirement for significance of four times their P.E. limits us considerably in possible deductions. However, we are still no doubt safe in challenging as a safe measure of intelligence in the lower grades an instrument involving a large linguistic element and which depends upon scores made under time limits. For we

TABLE IV

SHOWING TOTAL, PARTIAL, AND MULTIPLE CORRELATIONS, AND PROBABLE ERRORS AMONG VARIOUS FACTORS[1] FOR THE FIFTH GRADE

12	.08±.12	13	.32±.11	14	.18±.12	23	.17±.12
12.3	.03±.13	13.2	.31±.17	14.2	.20±.12	23.1	.16±.12
12.4	−.01±.13	13.4	.28±.12	14.3	.11±.12	23.4	−.06±.13
12.34	.03±.13	13.24	.28±.12	14.23	.15±.12	23.14	−.10±.12
24	.80±.04	34	.26±.11	1.23	.32±.11	2.13	.18±.12
24.1	.80±.05	34.1	.21±.12	1.24	.21±.12	2.14	.81±.04
24.3	.80±.05	34.2	.20±.12	1.34	.33±.10	2.34	.81±.04
24.13	.80±.05	34.12	.15±.12	1.234	.35±.10	2.134	.81±.04

[1] The factors correlated are designated by numbers as follows:
1. Criterion. Stanford-Binet tests.
2. National Intelligence test.
3. Non-linguistic rate tests. Pressey Primary and Kingsbury combined.
4. Linguistic rate tests. Intermediate Classification and Directions combined.

cannot overlook the fact that the non-time-limit Stanford-Binet does not correlate significantly with any timed test, while there is a high correlation between timed tests with the linguistic element.

It is impossible to say to what extent the low correlations in this grade are due to the narrow range of I.Q.'s. Below are given the probable errors of the distribution of the National raw scores, of the average I.Q.'s, and of the Mental Ages for the three grades.

PROBABLE ERROR OF DISTRIBUTION

Grade	National	Av. I. Q.	M. A.
5.	24.75	8.80	8.80
6.	30.50	9.17	13.50
7.	23.40	9.34	13.80

Especially in mental age distribution the fifth grade is much narrower than the others. The lower P.E. for the National in the seventh grade is no doubt due in part to the restriction in amount of scores imposed by the limits of the tests.

It is a fact, further, that the non-linguistic rate test does not contribute to the correlation of the National with the Stanford, since $r_{2.14} = .81$ and $r_{2.134} = .81$.

Table V shows the correlations from the sixth grade data. All coefficients of the zero order except one (r_{13}) meet the requirements for significance of four times the P.E.

The influence of the rate factor is shown clearly in the multiple correlations. The correlations of all the factors measured by the Stanford-Binet with all the factors measured by the National

Intelligence test is .76. The same coefficient is obtained for the National Intelligence test with the Linguistic Rate tests. The partial correlations, however, show that each of these three tests possesses different factors or the same factors in different degrees. Since $r_{2.14} = .87$ and $r_{2.134} = .88$, it is evident that the non-linguistic rate test does not influence materially the correlation

TABLE V

SHOWING TOTAL, PARTIAL, AND MULTIPLE CORRELATIONS AND PROBABLE ERRORS AMONG VARIOUS FACTORS[1] FOR THE SIXTH GRADE

12	.76±.05	13	.33±.11	14	.53±.09	23	.54±.09
12.3	.73±.06	13.2	.15±.12	14.2	.12±.12	23.1	.47±.10
12.4	.65±.07	13.4	.05±.13	14.3	.44±.10	23.4	.21±.12
12.34	.65±.07	13.24	−.12±.12	14.23	−.06±.13	24.14	.23±.12
24	.76±.05	34	.56±.09	1.23	.77±.05	2.13	.82±.04
24.1	.65±.07	34.1	.48±.09	1.24	.76±.05	2.14	.87±.03
24.3	.65±.07	34.2	.27±.12	1.34	.53±.09	2.34	.77±.05
24.13	.53±.09	34.12	.13±.12	1.234	.77±.05	2.134	.88±.03

[1] See note under Table IV.

between the Stanford and the National. The significant factors in producing the correlations shown are contained in the criterion, the National, and the linguistic rate tests.

The correlations $r_{1.24} = .76$ and $r_{12} = .76$ show that the linguistic rate tests do not contribute to the National any factor not already contained in the latter so far as its correlation with the criterion is concerned. The correlation r_{24} shows further that the National and the linguistic rate tests have much in common. The factors, then, that are measured by the linguistic rate tests are also measured fully by the National.

The question as to whether the National and the linguistic rate tests emphasize factors not contained in the criterion leads us to consider the effect of combining the rate tests with the Stanford for the highest correlation with the National. $r_{12.4} = .65 \pm .07$ is an indication of the closeness of the relation between the Stanford-Binet and the National when factors measured by the linguistic rate test are held constant. Now $r_{2.14} = .87$, while $r_{12} = .76$. That is, when we correlate the National with the best weighting of the Stanford-Binet and the linguistic rate tests combined we get a coefficient which shows the degree to which the National contains the rate factor independently of any signifi-

cance for intelligence. The lowering of the coefficient by eliminating rate, $r_{12.4} = .65$, indicates that rate is a factor in intelligence as contained in our criterion; while $r_{2.14} = .87$ shows that we must add rate elements to the Stanford-Binet to offset the excess in the National.

The seventh grade (Table VI) presents a somewhat different situation from either of the other two with reference to our

TABLE VI

SHOWING TOTAL, PARTIAL, AND MULTIPLE CORRELATIONS AND PROBABLE ERRORS AMONG VARIOUS FACTORS[1] FOR THE SEVENTH GRADE

12	.34±.11	13	−.23±.12	14	.22±.12	23	.18±.12
12.3	.40±.10	13.2	−.31±.11	14.2	−.09±.13	23.1	.26±.12
12.4	.28±.12	13.4	−.37±.11	14.3	.37±.11	23.4	−.32±.11
12.34	.18±.12	13.24	−.31±.11	14.23	.08±.13	23.14	.24±.12
24	.80±.04	34	.44±.10	1.23	.45±.10	2.13	.41±.10
24.1	.79±.05	34.1	.52±.09	1.24	.34±.11	2.14	.82±.04
24.3	.82±.04	34.2	.50±.09	1.34	.43±.10	2.34	.82±.04
24.13	.79±.05	34.12	.52±.09	1.234	.46±.10	2.134	.83±.04

[1] See note under Table IV.

problem. The extent to which differences in reading rate and practice in taking tests have entered into these group differences and also into the differences between results from these groups and the results from groups measured by other investigators, is beyond the scope of this study.

The results here agree with those of the other two groups in showing that the non-linguistic rate factor plays but little part in the correlations we are considering. They also agree with the results in the other groups in showing a marked correlation between the linguistic rate tests and the National.

There is a striking absence of significant correlations between the Stanford-Binet and any of the other measures. The correlation of .80 between the National and the linguistic rate is raised to only .83 when the best weighting of the two rate factors is combined with the Stanford-Binet. This fact indicates that the National Intelligence test is a much better measure of such rate factors as are measured by our rate tests than it is of the factors measured by the Stanford-Binet.

So far we have observed the influence of the rate factor in the grades separately. We have, also, observed that the different

grades show different degrees of relationship when the same pair of traits is considered. In other words, the results from the three grades are not in absolute agreement in many cases as to the

TABLE VII

SHOWING AVERAGE GRADE CORRELATIONS, PARTIAL AND MULTIPLE CORRELATIONS, AND AVERAGE DEVIATIONS AMONG THE VARIOUS FACTORS[1] FOR THE THREE GROUPS

12	.39	.24	13	.14	.25	14	.31	.12	23	.30	.16
12.3	.39	.24	13.2	.05	.24	14.2	.14	.10	23.1	.29	.11
12.4	.31	.23	13.4	−.03	.24	14.3	.31	.16	23.4	−.06	.18
12.34	.29	.24	13.24	−.05	.28	14.23	.06	.08	23.14	.12	.15
24	.79	.01	34	.42	.10	1.23	.51	.18	2.13	.47	.20
24.1	.75	.06	34.1	.40	.13	1.24	.43	.21	2.14	.83	.02
24.3	.76	.07	34.2	.32	.12	1.34	.43	.07	2.34	.80	.02
24.13	.71	.12	34.12	.27	.17	1.234	.53	.16	2.134	.84	.03

[1] See note under Table IV.

degree of relationship existing among the various measures. It is necessary, therefore, that we combine the results from these grades if we are to know what general tendency is representd in our results.

Two methods have been employed in bringing together the results from the three tables of correlations already discussed. Table VII shows the average of the grade correlations shown in Tables IV, V, and VI. This table shows the mean tendency in the relationships of the various factors. Table VIII presents the correlations obtained when we throw together the scores of the 87

TABLE VIII

SHOWING TOTAL, PARTIAL, AND MULTIPLE CORRELATIONS AMONG VARIOUS FACTORS[1] FOR ALL GRADES COMBINED

12	.64	13	.33	14	.56	23	.57
12.3	.58	13.2	.05	14.2	.02	23.1	.49
12.4	.35	13.4	.02	14.3	.47	23.4	.07
12.34	.35	13.24	.00	14.23	.00	23.14	.01
24	.88	34	.62	1.23	.64	2.13	.74
24.1	.82	34.1	.55	1.24	.64	2.14	.90
24.3	.83	34.2	.29	1.34	.56	2.34	.89
24.13	.77	34.12	.30	1.234	.64	2.134	.90

[1] See note under Table IV.

subjects for each test and correlate them as a whole. There are certain advantages peculiar to each method which will be discussed in connection with the two tables.

Before entering into a discussion of the meaning of the correlations in these two tables, however, some justification should be

given for omitting the age factor from the partial and multiple correlations. There are two reasons for the omission. In the first place, the three groups dealt with here represent highly selected cases in which age correlates from very low to negatively with the other factors. There is a tendency for the younger children in each grade to have the higher mental ages, whereas in unselected cases there would be a substantial positive correlation between chronological age and mental age. If, then, we include the age factor, influenced as it is by selection, in our partial and multiple correlations, we are including a factor whose *obtained* correlation with the other factors cannot be the *true* correlation. In the case of the National Intelligence test and chronological age, for example, we find grade correlations of —.23, —.33, and —.06 for the fifth, sixth, and seventh grades, respectively. When, however, the three grades are thrown into a single table the correlation is .28.

In the second place, we are concerned here chiefly with the question of the relative significance of speed of work in the measurement of intelligence by means of timed and non-timed tests. If, then, the omission of the age factor should introduce a constant error its influence would be chiefly to change the absolute amounts of the correlations rather than the relative amounts. The correlation between the coefficients in Tables VII and VIII is .95.

Our next problem is to study the implications of the combined correlations in order to see what they may contribute to the solution of our problem. We shall confine the discussion chiefly to the implications of the multiple correlations resulting (1) when the criterion is correlated with the best combination of the other factors, and (2) when the National is correlated with the best combination of the other factors; that is, $r_{1.23\cdots n}$ and $r_{2.13\cdots n}$. We shall present also the correlations from both Tables VII and VIII, so that in connection with the discussion of any point the relative changes in the correlation resulting from the inclusion or exclusion of the various factors may be observed in both tables. It should be kept in mind that Table VII represents the averages

of the grade correlations, while Table VIII gives the correlations when the 87 cases are thrown together in the several tests, but without any attempt to control the age factor.

Whenever there is a discrepancy between the correlations in the two tables we shall assume that the difference in either case is unreliable. We have also determined the limits within which differences do not equal or exceed four times their probable error. By obtaining the probable error of the difference between coefficients, we find that with a correlation of .30 a difference of .04 is significant and that with a correlation of .80 a difference of .01 is significant. It is also true that correlations of .30 and above are four times their probable error in these tables.

It is evident from this table that the linguistic rate test does not measure any factor involved in the criterion which is not measured by the National Intelligence test or the non-linguistic rate tests. This is shown when we combine the different factors by multiple correlation so as to get the highest correlation with the criterion.

	Table VII	Table VIII
$r1.23 =$	.51	.64
$r1.234 =$	.53	.64

From this it is seen that practically nothing is contributed by the linguistic rate factor. A correlation of .51 is raised to only .53 by including the linguistic rate factor.

That the rate factors, especially the non-linguistic, contribute something to the National as a measure of intelligence is shown by the following correlations:

	Table VII	Table VIII
$r12 =$	.39	.64
$r1.23 =$	.51	.64
$r1.34 =$	.43	.56
$r1.234 =$	.53	.64

Observe first that a correlation of .39 between the criterion and National is raised to .53 when the two rate factors are combined with the latter. Again, it is notable, in this connection, that the two rate factors when combined correlate with the criterion slightly in excess of the coefficient obtained between the National and the criterion.

Next, let us analyze the results when the criterion is combined

with the two rate factors to give the highest correlation with the National Intelligence test. If we examine the correlations below we find that the rate tests and the National Intelligence test measure factors largely independent of those measured by our criterion.

	Table VII	Table VIII
$r24 =$	.79	.88
$r24.1 =$	.75	.82

When we keep constant the factors measured by the criterion which may be present also in both the National and the rate tests, we find that the correlation resulting is reduced but slightly. And if we combine the criterion with the rate tests for the best correlation with the National the coefficient is but slightly higher than the total correlation between the National and the rate tests.

	Table VII	Table VIII
$r24 =$	.79	.88
$r2.14 =$	.83	.90

These facts seem to justify the conclusion that the factors measured by the rate tests and by the National Intelligence test are to a very large extent identical.

To what extent are these factors also identical with factors in our criterion?

The following correlations show the relation between the criterion and the National and between the criterion and the rate tests, respectively:

	Table VII	Table VIII
$r12 =$	.39	.64
$r1.34 =$	.43	.56

These probably mean that there is not a reliable difference between the two correlations. This is but another way of saying that the rate tests and the National maintain about the same degree of relation with the criterion.

If we take the two correlations,

	Table VII	Table VIII
$r2.34 =$	.80	.89
$r2.134 =$	.84	.90

it is evident that the criterion may be left out with but little loss in the degree of relationship. But if we compare the following correlations,

	Table VII	Table VIII
$r1.34 =$	.43	.56
$r1.234 =$	.53	.64

we find that the National does contribute slightly factors which are not included in the rate tests. The correlations,

	Table VII	Table VIII
$r1.34 =$	.43	.56
$r2.34 =$	.80	.89

show the degree of correlation of the criterion and of the National Intelligence test, respectively, with the rate tests combined.

The implications of these correlations are, first, that the criterion is a relatively poor measure of rate of response; second, that the National Intelligence test is a relatively good measure of rate of response; and third, that the National is a better measure of what is measured by the rate tests than it is of what is measured by the criterion.

It was hoped that by using as rate measures tests of slightly different difficulty we might get data for studying the relation

TABLE IX

SHOWING THE MEDIANS, DIFFERENCES OF MEDIANS, AND P.E. OF DIFFERENCES FOR THE VARIOUS GRADES AND DIFFICULTIES. I, II, AND III STAND FOR THE THREE DEGREES OF DIFFICULTY FROM EASY TO MOST DIFFICULT

Grades	Medians			I and II		II and III	
	I	II	III	Difference	P.E. of Dif.	Dif.	P.E. of Dif.
5	12.5	8.4	7.3	4.1	.744	1.1	.653
6	17.5	14.5	11.5	3.0	.815	3.0	.749
7	19.0	16.5	14.0	2.5	.776	2.5	.698
Median [1]	16.0	13.4	11.2	2.6	.617	2.2	.539

[1] The medians, differences, and P.E. of differences in the last row are determined from distributions of all the scores in each of the three degrees of difficulty.

of rates at different degrees of difficulty to intelligence, and at the same time not seriously interfere with the original requirement for a rate test. It seems, however, that the slight differences in degrees of difficulty and the very small amount of time given to each different degree have operated to make the correlations somewhat inconsistent in some places. We are, nevertheless, presenting the results and indicating some of the implications which seem to be most justifiable.

Table IX is presented especially to show the amount and significance of the differences between the different degrees of

difficulty of the rate tests. Greater degrees of difference in difficulty between these tests would have brought out better the influence of the difficulty factor.

Two questions will be considered in connection with these measures of rate at different degrees of difficulty. We wish to

TABLE X

SHOWING THE AVERAGE OF THE TOTAL, PARTIAL, AND MULTIPLE CORRELATIONS AND AVERAGE DEVIATIONS AMONG VARIOUS FACTORS[1]

12	=.39	.24	12	= .39	.24	12	=.39	.24
13	=.31	.0	14	= .25	.19	15	=.32	.18
23	=.72	.05	24	= .76	.19	25	=.79	.02
12.3	=.26	.25	12.4	= .34	.24	12.5	=.01	.40
13.2	=.06	.10	14.2	=−.07	.12	15.2	=.04	.18
13.4	=.17	.09	14.3	= .01	.19	15.3	=.15	.17
13.5	=.06	.13	14.5	= .05	.03	15.4	=.24	.11
34.1	=.79	.03	35.1	= .78	.04	45.1	=.80	.07
34.5	=.36	.26	35.4	= .44	.09	45.3	=.51	.11
23.1	=.67	.10	24.1	= .71	.09	25.1	=.74	.10
1.23	=.45	.21	1.24	= .42	.20	1.25	=.50	.14
2.13	=.79	.03	2.14	= .81	.03	2.15	=.83	.01
3.12	=.73	.05	4.12	= .76	.03	5.12	=.80	.03
1.345	=.44	.11	3.145	= .86	.01	4.135	=.87	.02
			5.134	= .87	.05			

[1] The factors correlated are designated by numbers as follows:
1. Criterion. Stanford-Binet Tests.
2. National Intelligence Test.
3. Linguistic rate test of least degree of difficulty, I.
4. Linguistic rate test of slightly greater degree of difficulty, II.
5. Linguistic rate test of greatest degree of difficulty, III.

consider the influence of the different degrees of difficulty upon the correlations of rate, (1) with the National, and (2) with the criterion. It should first be pointed out, however, that the correlation of the rate tests and the National with each other give much more consistent correlations for the three grades than does either with the criterion. This is shown clearly by the average deviations in Table X.

The following average coefficients from Table X show that the slight difficulty differences in the rate tests are concerned in the correlation:

$$r23 = .72 \qquad r24 = .76 \qquad r25 = .79$$

This comparison is offered with the reservation that the possible effect of practice upon the correlations in the cases of the second and third degrees of difficulty has not been determined. These correlations were obtained from the following total correlations:

Grade	r_{23}	r_{24}	r_{25}
5	.793	.77	.82
6	.654	.72	.76
7	.723	.778	.786

In only one case, $r_{24} = .77$ in the fifth grade, is there a failure of the correlation between the National and the rate tests to increase with the increase difficulty of the rate test. This exception is no doubt due in part to the narrower range of ability in the fifth grade already pointed out.

The fact that this relationship is independent of those factors in the National Intelligence test and in the rate tests which are common to the criterion is shown by the partial correlations,

$$r_{23.1} = .67 \qquad r_{24.1} = .71 \qquad r_{25.1} = .74$$

This indicates again that the National is primarily a rate test of the linguistic type. It also indicates that a single short rate test gives a very good measure of this rate factor.

What is the relation of the rate factor to the criterion? In general, the answer is that the relation is small. The total correlations between the criterion and the rate tests of different degrees of difficulty show a low coefficient, .30, A. D. .028.

The correlation of the National with the criterion is only slightly improved by combining in the best weighting the National with the rate tests of different degrees of difficulty. In fact, this secures coefficients only slightly higher than are obtained between the criterion and the rate tests of the three degrees of difficulty, leaving the National out. The correlations for these are:

$$r_{1.23} = .45 \qquad r_{1.24} = .42 \qquad r_{1.25} = .50 \qquad r_{1.345} = .44$$

It should be kept in mind, too, that factors 3, 4, and 5 were measured in 100 seconds each, or a total of five minutes working time. This correlation between rates and criterion is somewhat better than is obtained by the National and the criterion, *i.e.*, $r_{12} = .39$.

V. SUMMARY AND CONCLUSIONS

A. Procedure. In this study of the relation of rate of response to intelligence two essential features should be noted:

1. The Tests. Three sets of tests were employed: (a) The criterion is the average of I.Q.'s obtained from yearly tests with Stanford-Binet for periods of from one to four years. (b) The scores from National Intelligence tests A and B are taken as a measure of factors present in the criterion as well as of possible factors which might be independent of the criterion. (c) Linguistic and non-linguistic rate tests were employed to measure the possible factors in the National Intelligence test which might be independent of the criterion. These tests provided the basis for studying the rate factor with and without the linguistic element. One of two linguistic rate tests was composed of three parts differing slightly in difficulty, so as to provide the basis for studying influence of rate at different levels of difficulty upon intelligence measurements.

The reliability of the tests was determined in each instance. A fairly high degree of reliability (about .80) was found where the self-correlation method was applicable. The only tests for which a high degree of reliability could not be shown were the non-linguistic rate tests. These gave a correlation of .67 between tests of somewhat different material.

2. Method of Treatment. The correlation method was employed throughout. Pearson's product-moments method was employed in the zero-order correlations. The formulae as given by Yule were used in the partial and multiple correlations. The reliability of individual coefficients is given, as is also the reliability of the difference between coefficients where differences are important.

The data from the three groups of subjects were treated first without disturbing these groupings. The averages of the various correlations, as well as the original coefficients, were tabulated.

The data for the three groups were then thrown together and treated as a single array.

The results are analyzed for two purposes. The data were studied, first, for the purpose of finding out how important the rate of response factor was in the measurement of intelligence; and second, for the purpose of finding what relation existed between rates based on material of different degrees of difficulty and intelligence.

B. Conclusions:

1. The results of this investigation indicate decidedly that the rate of response to test material is by no means a safe measure of intelligence.

2. They indicate, also, that the National Intelligence test is a much better measure of rate of response than it is of intelligence.

3. The simple linguistic rate tests used in this study are about as good a measure of intelligence as is the National Intelligence test.

4. Rate in linguistic material can be measured much more consistently by a short test than rate in non-linguistic material.

5. The non-linguistic rate tests, when added to the National, contribute slightly more to the correlations with the criterion than does the linguistic rate.

6. The high correlation between rate tests and the National Intelligence test points to a danger in employing the composite of group tests as a criterion by which the validity of a new group test is tested. It may be that this process is increasing the importance of the rate element in group tests at the expense of factors more significant of general intelligence.

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VOL. XXXIV
NO. 4

PSYCHOLOGICAL REVIEW PUBLICATIONS

WHOLE NO. 157
1925

Psychological Monographs

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An Experimental Study of Retention and Its Relation to Intelligence

By

Ang Lanfen Lee, Ph.D.

PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.
and ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.); Leipzig (Hospital St., 10); Paris (76, rue de Rennes)

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v.34

To my father

ACKNOWLEDGMENTS

The writer is deeply grateful to Professor Arthur I. Gates for his constant supervision and encouragement throughout the experimental study. She is also indebted to Professors E. L. Thorndike and Paul Monroe for inspiration and interest. She wishes to thank Dr. Clara Chassell Cooper, Miss W. Phillips, Principal of Public School No. 188, and Mr. J. D. Reardon, Principal of Public School No. 23, of New York City, who have rendered her valuable assistance. Grateful appreciation is due to Mr. L. N. Lau, who read the proof of this monograph.

Sample retention tests and original scores of this study will be supplied upon request.

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CHAPTER 1

THE PROBLEM STATED

The development of experimental psychology has thrown much light upon the true nature of memory. Laws such as those of frequency, recency, primacy, and vividness have been formulated. The theory of improvability of memory was supplanted by a sounder doctrine that its utility can be increased only through wiser application of the laws of association. The traditional supposition of the intellectual quality of memory has been confirmed by several studies. Retention tests have been included in various up-to-date instruments for measuring intelligence. To determine experimentally, and on a relatively large scale, the correspondence between general intelligence and retention, seems, therefore, to be both of direct theoretical interest to the science of psychology and of practical importance to mental measurement. It was with this purpose in mind that the present investigation has been primarily designed. In order to obtain reliable measures of retention, the study in this field has been extensive. Steps have been taken to examine the relation between retention during relatively short intervals and during relatively long intervals. The questions the present investigation has aimed to answer are:

1. To what degree is there correspondence between general intelligence and retention as it is measured by the method of recall?

2. To what degree is there correspondence between general intelligence and retention as it is measured by the method of recognition?

3. Will the degree of correspondence between general intelligence and retention vary as the materials to be retained vary? If so, how much?

4. If a person retains well during an interval of about 30 seconds, to what degree will he maintain his relative efficiency during an interval of about 24 hours? What differences are to be found in this relationship for different kinds of material?

5. What differences are to be found in the relationships between general intelligence and retention during a relatively short interval, and during a relatively long interval?

6. What correlations exist between efficiency in retention for different kinds of material and general intelligence?

7. Is the form of the function or the content used the more influential factor in determining the correlations between retention tests?

8. What relationship is to be found between the retention of different kinds of material?

CHAPTER II

METHOD AND PROCEDURE

1. Materials

A. Measurement of Intelligence:

For a group of nearly four hundred subjects it was found convenient to employ group tests. A set of widely recognized verbal group tests, the National Intelligence Tests, was chosen to serve this purpose. The composite score on Form A and Form B of these tests was used as the measure of intelligence. The writer realizes that there are other ways of formulating possibly fuller and more reliable criteria of general intelligence than the one adopted here. However, circumstances have limited the scope of the experiments. To avoid misinterpretation the reader should bear in mind the particular measure of general intelligence utilized in this investigation.

B. Retention Tests:

Strength of retention varies with the materials to be retained. It was considered necessary that the present investigation should include in the retention tests a variety of material in order to secure reliable measures of retention. Four kinds of material, pictures, words, geometrical forms, and nonsense syllables were included in the tests. For each kind of material there are two alternative presentation series and two recognition tests. When one series was used for recall the other was used for recognition. On each presentation card there are 25 items, 25 pictures, 25 words, etc. On each recognition test there are 50 items, half of which were the same as those on the presentation card. The 25 words or 25 syllables were printed in eight point Scotch type in single column on the presentation card, and in two columns on the recognition test. The 25 forms or 25 pictures are printed

in five columns on both the presentation card and the recognition test. The 50 pictures, with enough space between them, occupy a sheet 6 x 9 inches. The 50 forms occupy a sheet 5 x 8 inches. Each card is headed by the word, words, or syllables according to the material.

The words are all simple nouns such as cream, plant, etc., the pictures are those of objects common in every day existence, such as automobile, clock, etc. In previous memory experiments pictures of concrete objects have not been as extensively used as other kinds of material. The picture tests used in this study have been compiled by the writer. Most of the pictures were gathered from Myers' Mental Measures, and a few from other sources. Precaution was taken to avoid including in the word tests the names of objects in the picture tests. The geometrical form tests are similar to those used by Whitley, Simpson, and later by Achilles. The nonsense syllables tests are also similar to those used by Achilles.[1]

2. Subjects

Three hundred and eighty-nine children participated in the experiment. However, since the testing covered two consecutive days, many subjects were lost on account of the incomplete records. Thus only the results of three hundred and ten subjects were treated statistically. They ranged from the third to the eighth grade. The youngest subject was seven years and eleven months old, and the oldest sixteen years and three months. The average of their ages is eleven and a half years. About half of the children belonged to Public School No. 23, and the other half to Public School No. 188 of Lower Manhattan, New York City. A large proportion of the children were of foreign parentage. The children themselves, however, have been attending public schools for years. Approximately one-fourth of the subjects were boys, and three-fourths girls.

[1] See Achilles, E. M. Experimental Studies in Recall and Recognition. *Archives of Psychol.*, No. 44, Chap. IV.

TABLE I
Grade

Age in months	IIIb	IVa	IVb	Va	Vb	VIa	VIb	VIIa	VIIb	VIIIa	VIIIb	
95	7											7
100			2									2
105	1		1									2
110			1	2								3
115			1	3								4
120					7	8						15
125				1	1	21	5					28
130						4	10	1	3			18
135	1		3				4	1	5			14
140		1		2		2	4	5	7	2		23
145		1		2	2	6	8		9	1	1	30
150					2	6	6		1	6	1	22
155						6	8			5	2	21
160			1		2	5	5	1	1	5	4	24
165						2	4	3	3	3	8	23
170					1	2	3	2	5	9	7	29
175						2	2	3	2	6	6	21
180						2		1	1	7	6	17
185										3	2	5
190												
195										1	1	2
	9	2	9	10	15	66	59	17	37	48	38	310

3. Method of Giving the Tests.

The 30-Seconds Retention Test:

The subjects were tested in groups of from thirty to forty each. The testing was done on two consecutive days. On the first day the 30-seconds retention test took place. Material series A was used for recall and series B for recognition. The presentation cards were presented in the following order: Words, nonsense syllables, geometrical forms, and pictures. The time allowed to study each card was 50 seconds, at the end of which the card was taken away from the subject. Thirty seconds after the study period (50 seconds) the subjects were requested to reproduce on a piece of paper as many items as they could remember. For pictures the name of the objects instead of the pictures were reproduced. Presentation of series B in the same order followed immediately. Thirty seconds after the study period the subjects were requested to turn over a recognition test already on the desk, and mark with the letter *y* the items which he remembered seeing on the presentation card and with the letter *n* the items which he did not remember seeing on the presentation card. No time limit was set for reproducing series A and for marking the recognition tests. The length of time so taken was, however,

carefully observed. For recall it ranged from two minutes for the quick children to five minutes for the slow ones. After that limit almost no one expressed a desire to continue. For marking the recognition tests the quick ones took about one minute, while the slow took about four minutes. On the whole, more time was spent on words and forms and less on pictures and nonsense syllables.

The 24-Hour Retention Test and the Relearning Test:

On the second day at the same hour, that is approximately 24 hours after the 30-second retention test, the same group of children was retested for their retention of the materials presented the day before. The recall test preceded the recognition test, and all kinds of material were either recalled or recognized in the previous order.

After the 24-hour retention test the children were encouraged for their good work. But the experimenter expressed a desire to obtain an accurate knowledge of their retentive power, in order to pass sound judgment. This accurate knowledge could be secured only through their effort to go over all the presentation cards once more and have their memory retested. Presently the relearning test was carried out. Procedure and length of interval of the relearning test followed the same steps as the 30-seconds retention test, except that material series B was used for recall and series A for recognition.

4. Precautions.

Every precaution was taken to maintain uniform conditions for all the groups. They were tested in ordinary class rooms. The writer took much pains to train herself in conducting the tests. She was introduced to the children by teachers and visited the classes several times before starting the experiments. Trial experiments were conducted on about fifty children in groups of seven or eight each. These children and their classmates were not expected to participate in the regular experiments, and the scores on tests were not used in statistical work of this study.

Instructions were written and memorized in order that the experimenter might be able to give them orally, and at the same time have an eye on the subjects. Instructions for the 30-seconds retention test are as follows:

"I am going to show you some things and afterwards find out how much you can remember. Sometimes I shall show you words, sometimes forms, such as a circle or a square, sometimes nonsense syllables—nonsense syllables always have three letters put together in such a way that they do not make sense—and sometimes pictures. Sometimes I shall find out how much you can remember by asking you to write down afterwards how many you remember, and sometimes by showing you them again mixed with some that you have not seen before. There will always be twenty-five things to study and you will always be given fifty seconds in which to study them. In order that you may have some idea of how long that time is, I shall show you a picture for fifty seconds before we begin.[2]

"There are some cards on each of which there are 25 words. I am going to give one of these cards to each of you with the printed side down. Leave it on your desk. Do not turn it over. When I say 'go' you turn the card and study the words. Remember you have only 50 seconds to study them. Be sure to study all the words" (or syllables, etc.).

In order to prevent any possible tendency to cheat, the children were requested to shift their seats so that they would not be sitting next to their habitual neighbors. In all the class rooms, where the testing was conducted, seats were arranged in single file with considerable distance between. Under these conditions it was not laborious for the teacher and the experimenter to watch over the children.

Children were not told that they would be tested again after 24 hours. After the 24-hours retention test they were asked whether they had thought or talked about the tests given on the previous day. Among each group there were several who said that they did talk with their friends or members of their

[2] This part of the instruction was similar to that used by Dr. Edith Mulhall Achilles. See her "Experimental Studies in Recall and Recognition," p. 32.

families about their novel experience, but did not attempt to preserve what they studied. After the relearning test it was expected that the children would endeavor to remember the material with the suspicion that they might be tested again. Therefore, it was not thought advisable to give another 24-hour retention test, which if satisfactorily obtained, might have served in checking up the results.

National Intelligence Tests:

Since the retention tests covered two consecutive days, it was convenient to give Form A one day and Form B on the other. For all groups one form was given in the morning and the other in the afternoon. The writer was responsible for testing the children in Public School No. 23. The children in Public School No. 188 were tested by Miss Grace Taylor, a fellow research student in Teachers College, Columbia University.

5. Method of Scoring

For scoring recognition tests the method of " all rights minus wrongs " was adopted.[3] For recall only the correctly reproduced items were counted, and no partial credit was given. A perfect score on any recall test is 25, and on any recognition test is 50.

[3] For full discussion on this method see Achilles, *op. cit.*, p. 26 ff.

CHAPTER III

DISTRIBUTION OF SCORES

1. The Range of Age and the Range of Intelligence.

As has been stated in the foregoing chapter, the subjects of the present investigation were drawn from the third to the eighth grade. Their ages ranged from seven years and eleven months to sixteen years and three months with an average of eleven and one-half years. The distribution of age in months is found in Table I and the grade distribution in Table II. Their total raw scores made on Forms A and B of the National Intelligence Tests go as low as 25 points and as high as 310 points. The average is 197.07 points. (S. D. 48.20.) Since half the children were not taken at random, but on the contrary were estimated by the teachers as belonging to two distinct groups, the bright and the dull, the calculation of the mental index was desired in order to enable a comparison of the distribution of these indices with that of the raw scores. The indices ranged from 66 to 142, with an average of 98.2. (S. D. 17.50.) The frequency polygons for the same data on page 42 show that the distribution of raw scores has a very slight positive skewness, while the distribution of the mental indices calculated therefrom has a considerable negative skewness. These phenomena are explained by the fact that a relatively large proportion of the children came from the upper grades and a relatively small proportion from the lower. Besides, there are relatively more dull ones among the upper grade children than among the lower. Thus we have a distribution of intelligence scores more nearly symmetrical than that for the mental indices calculated from the same data.

2. Distribution of Scores on Retention Tests

Distribution of scores on the test of retention after a 30-seconds interval and the test of retention after a 24-hours interval

and the relearning test for each of the four kinds of material are represented by frequency polygons on pp. 39–41. The averages, standard deviations, and medians are given in Table III. For purposes of comparison, the three polygons for each kind of material are graphed on the same scale. An inspection of the polygons shows that the scores on most of the tests are well distributed with the exception of those on the test of recall of words after a 24-hour interval and on the three recall tests of

TABLE II

P=picture test, w=word test, f=geometrical form test, s= nonsense syllable test; 1=30-seconds retention test, 2=24-hour retention test, 3=relearning test.

Tests	Recognition			Recall		
	Average	S. D. from ave.	Median	Average	S. D. from ave.	Median
p1	32.2	9.57	35.8	12.4	3.35	12.8
p2	22.9	10.32	24.1	7.4	2.97	7.5
p3	34.8	10.89	37.4	15.1	4.27	15.3
w1	31.2	11.73	32.1	9.6	4.53	9.0
w2	16.7	9.57	17.5	4.5	2.92	4.1
w3	31.7	12.03	35.2	13.3	4.83	13.6
f1	10.7	7.74	10.3	5.1	2.30	5.0
f2	7.2	7.23	6.5	4.0	1.84	4.0
f3	13.4	9.66	12.5	7.1	2.57	7.1
s1	13.8	8.82	14.1	3.6	2.59	3.1
s2	4.9	7.29	5.5	1.5	0.96	1.3
s3	13.5	8.37	13.0	5.1	3.34	4.5

syllables. To make the statement more precise, for all kinds of material, perhaps with the exception of syllables, when retention is tested by the method of recall and the interval is approximately 30 seconds, a 50-seconds period of study is a fair length to insure a satisfactory distribution of scores. When the recognition method is used, and with the same length of interval, a 50-seconds period of study, however, proves to be slightly too long for the picture test and the word test, since a considerable number of subjects made perfect scores. In the test of retention after the 24-hour interval the scores on the recognition tests for all kinds of material are fairly well distributed. Distribution of scores on the test of recall after a 24-hour interval however, shows that with the exception of the picture test, a 50-seconds period of study is so short that a large number of subjects made zero scores.

In order to avoid undistributed scores at the extremes, it would have been a wiser plan to vary the amount of material and keep the length of study period only constant. In this investigation, however, interest is mainly concerned in the correlation between general intelligence and retention as tested by the two methods, recall and recognition, under constant conditions. In the retention test using a 24-hour interval, although the distribution of scores for recall of most of the materials are skewed, the distributions of scores for recognition of all kinds of material are symmetrical, and in the tests of immediate retention, while there are some undistributed high scores in recognition there are none in recall.

CHAPTER IV

CORRELATIONS BETWEEN SCORES ON INTELLIGENCE TESTS AND SCORES ON RETENTION TESTS

In past experimental studies in correlation of mental abilities, retention has often been one of the chief objects of interest. Some of these studies were designed to examine the correlation between the various mental abilities and general intelligence. In some cases opinions of teachers and of associates, and in other cases school marks were used as the criterion of intelligence. The objectionable features of these methods of estimating general intelligence are twofold. In the first place, estimates of teachers and associates are subjected to personal prejudices, and interpretations of the factor to be estimated. Such estimates by different individuals are, therefore, comparable with each other only in a certain sense. They can be used with advantage when they are carefully checked against each other and against some standard measure. In the second place, the use of school marks as an index of general intelligence presupposes an absolute, or, at least, a very high correlation between the two. But the futility of such assumption is proved by the more recent experiments to determine the correlation between school achievements and general intelligence. The results of these signify that the so-called general intelligence has a much wider field of application than merely to learning of school subjects. Therefore, it is inadequate to measure general intelligence by school achievement alone. Moreover, the school marks used in some of the former experiments are at least theoretically less trustworthy than the school achievements measured by recent standard educational scales would be, since the former are based upon personal standards of accomplishment, while the latter are based upon the average accomplishment of a given educational group.

There are several reasons which warrant one to believe that the results of the present investigation are of greater scientific

value than those of the past studies on the same problem. In the first place, it has employed a standard measure of general intelligence—the National Intelligence Tests, Forms A and B. These sets of tests are widely recognized as one of the most reliable and searching among the available verbal group intelligence tests. Secondly, the study has attempted a measurement of retention in a more thorough manner than the past studies have done; with a greater variety of materials and with intervals of different lengths. Thirdly, it has three hundred subjects, a number considered sufficiently large to yield reliable data.

Pearson's product moment method was adopted for calculating correlations between scores on the National Intelligence Tests and scores on the retention tests.

1. Recall and General Intelligence.

Retention of meaningful and familiar material correlates higher with general intelligence than retention of material devoid of or meager in associations.

In Table III the coefficients of correlation between scores on intelligence tests and recall of pictures, and scores on intelligence tests and recall of words rank first and second in magnitude.

TABLE III

Coefficients of correlation between composite score on the National Intelligence Tests, Forms A and B and Recall: p=picture, w=word, f=form, s=syllable; 1=30-seconds retention test, 2=24-hours retention test, 3=relearning test.

N. I. T. (A & B)	with recall	p1	.58 = P.E.	.03
"	"	w1	.55 = P.E.	.03
"	"	f1	.23 = P.E.	.05
"	"	s1	.16 = P.E.	.05
"	"	p2	.46 = P.E.	.04
"	"	w2	.47 = P.E.	.04
"	"	f2	.27 = P.E.	.05
"	"	s2	.29 = P.E.	.05
"	"	p3	.53 = P.E.	.03
"	"	w3	.45 = P.E.	.04
"	"	f3	.39 = P.E.	.04
"	"	s3	.30 = P.E.	.05
Average.....			.39	

The average of the correlations between general intelligence and the three recall tests of pictures is .52; between the general intelligence and the three recall tests of words is .49; between general intelligence and the three recall tests of forms is .30;

and between general intelligence and the three recall tests of syllables is .25. There is a relatively wider range of difference in magnitude among the coefficients between general intelligence and recall of different kinds of material in the case of the 30-seconds retention test than in the case of the other two retention tests. In the 30-seconds retention test the coefficient of correlation between recall of pictures and general intelligence is .58, which is 3.6 times the coefficient of correlation between recall of syllables and intelligence, and 2.5 times that between recall of forms and general intelligence. There is but a slight difference between the coefficients of correlation of general intelligence with recall of pictures, and of general intelligence with recall of words.

With meaningful and familiar material, immediate recall correlates higher with general intelligence than delayed recall.

The coefficients of correlation between general intelligence and recall of pictures and general intelligence and recall of words after a 30-seconds interval are .58 and .55, respectively. The correlations between general intelligence and recall of these two kinds of material after a 24-hours interval are .46 and .47, respectively. Similarly the correlation between recall of pictures in the relearning test and intelligence (.53) is higher than the correlation between intelligence and recall of pictures in the 24-hours retention test. The correlation between recall of words in the relearning test and intelligence is, however, .02 lower than the correlation between recall of words in the 24-hours retention test and intelligence.

The coefficients of correlation between intelligence and the recall of forms and intelligence and the recall of syllables in the 30-seconds retention test on the whole are less in magnitude than the correlations between intelligence and recall tests for the same kinds of material in the 24-hours retention test. On the basis of these results, it may be concluded that with these kinds of material, delayed recall correlates higher with intelligence than does immediate. However, recall of these kinds of material gives a higher correlation with intelligence in the relearning test than in the 24-hours retention test.

2. Recognition and General Intelligence.

The correlation between recognition and general intelligence is lower than the correlation between general intelligence and recall.

The coefficient of correlation between intelligence and recognition of pictures in the relearning test is .37, which is the highest coefficient found between intelligence and recognition. In contrast with this, the highest among the coefficients between intelligence and recall of different kinds of material is .58, which is that found between intelligence and recall of pictures in the 30-seconds retention test. Thus there is a difference of .21 between the two highest coefficients. The average of all the correlations between intelligence and recall of different kinds of material is .39, while the average of all the correlations between intelligence and recognition is only .26. This difference in degree of correlation between recall and intelligence and recognition and intelligence is more prominent with material such as pictures and words, than with material such as forms and syllables. Recognition of pictures and recognition of words on the whole show a relatively high correlation with intelligence as compared with recognition of forms and recognition of syllables. The average of the three coefficients of correlation between intelligence and (1) recognition of pictures is .34, (2) recognition of words .27, (3) recognition of forms .19, and (4) recognition of syllables .26.

The coefficients of correlation between intelligence and recognition of the different kinds of material vary but slightly from each other.

Another point of contrast between the group of correlations of intelligence with recall of different kinds of material and the group of correlations of intelligence with recognition of different kinds of material is the fact that the range or variation in magnitude is wider in the former than it is in the latter. In the former the range is from .16 to .58, while in the latter it is from .13 to .37.

Recognition of each kind of material, however, does not maintain the same relative position in degree of correlation with

intelligence through the three retention tests as does recall. In the 30-seconds retention test recognition of words and recognition of syllables rank first and second in degree of correlation with intelligence. In the 24-hour retention test the first and the second

TABLE IV

Coefficients of correlation between composite score on National Intelligence Tests. Forms A and B and recognition: p=picture, w=word, f=form, s=syllables; 1=30-seconds retention test, 2=24-hours retention test, 3=relearning test.

N. I. T. (A & B)	with recognition	p1	.30=P.E.	.05
"	"	w1	.36=P.E.	.05
"	"	f1	.13=P.E.	.05
"	"	s1	.32=P.E.	.05
"	"	p2	.34=P.E.	.05
"	"	w2	.24=P.E.	.05
"	"	f2	.26=P.E.	.05
"	"	s2	.23=P.E.	.05
"	"	p3	.37=P.E.	.05
"	"	w3	.22=P.E.	.05
"	"	f3	.17=P.E.	.05
"	"	s3	.23=P.E.	.05
Average			.26	

ranks in degree of correlation with intelligence were taken by recognition of pictures and recognition of forms. In the relearning test, recognition of pictures and recognition of syllables are favored with a relatively high correlation with intelligence. Thus the data offer no definite information as to whether it is the kinds of material rich in associations, or the kinds of material devoid of or meager in associations that correlate relatively high with intelligence. Nor do the data indicate whether recognition after a relatively short interval or recognition after a relatively long interval, has a higher correlation with intelligence.

3. Retention and Age

Since the subjects of the present experiments vary in age, the correlations between age, and recall and recognition after a 30-seconds interval and a 24-hours interval, were computed.

Six of the correlations between age and recognition are negative quantities. The remaining two positive coefficients are very low. In contrast with these, there are only two negative quantities among the coefficients between recall of different kinds of material and age. The coefficient between recall of pictures and

age are moderately high. The data apparently show that, although there is fair positive correspondence between age and recall of pictures and recall of words, there is practically no correspondence between age and recall of other kinds of material and recognition

TABLE V

Coefficients of correlation between age and retention. p=picture, w=words, f=form, s=syllable; 1=30-seconds retention test, 2=24-hours retention test.

Age	with	recall	p1	.48,	recognition	p1	—.20
"	"	"	p2	.32,	"	p2	—.004
"	"	"	w1	.37,	"	w1	—.07
"	"	"	w2	.23,	"	w2	—.004
"	"	"	f1	.10,	"	f1	—.17
"	"	"	f2	.06,	"	f2	—.02
"	"	"	s1	.04,	"	s1	—.22
"	"	"	s2	.10,	"	s2	—.03

of all kinds of material for the group of subjects used. The low and negative correlations may be due partly to the large number of zero scores on some of the retention tests, and partly due to the factor of selection—that is there were relatively more bright children among the younger subjects and more dull ones among the older; the young and bright ones might have taken much interest in the tests while the bright but older might have thought of being fooled and thus did their work carelessly. However, these are but speculative explanations. In order to have a definite notion of the influence of these uncontrolled factors further experiments would be necessary.

Achilles adopted a method by which she obtained for each grade the average score for children whose age was the median age of that grade, and average score for children who were above and who were below the median age of the grade. On the basis of these averages she concludes: "There is a tendency for the scores of those who are younger than their classmates to be higher, except in the case of syllables. But the number of subjects is small in the group under 3 (meaning three years below the median age of the grade). The curves and the tables suggest that there is a tendency toward improvement by age and grade." [1]

[1] Achilles, E. M. *Archives of Psychology*, No. 44, 1920.

4. Correlation Between Retention and Intelligence With the Age Factor Eliminated.

The computation of the coefficients of correlation between age and retention leads to a further step in the inquiry—the question as to the degree of correlation between intelligence and retention for a single age group. In order to answer this the partial correlation method was employed to eliminate the age factor.[2] The formula is:

$$r12.3 = \frac{r12 - (r13)\ (r23)}{\sqrt{1 - r13^2}\ \sqrt{1 - r23^2}}$$

r12 = General intelligence and recall (or recognition, as the case may be).
r13 = Intelligence and age.
r23 = Recall (or recognition) and age.

The coefficients of correlation thus obtained are presented in Table VI. The coefficient of correlation between intelligence and age was found to be .31.

TABLE VI

Coefficients of correlation between intelligence and retention with the age factor eliminated; N. I. T.=National Intelligence Tests, Forms A & B, p=picture, w=word, f=form, s=syllable, 1=30-seconds retention test, 2=24-hours retention test.

N. I. T.	with	recall	(age	constant)	p1	.52,	with	recognition	(age	constant)	p1	.39
"	"	"	"	"	p2	.40,	"	"	"	"	p2	.36
"	"	"	"	"	w1	.50,	"	"	"	"	w1	.36
"	"	"	"	"	w2	.44,	"	"	"	"	w2	.26
"	"	"	"	"	f1	.28,	"	"	"	"	f1	.18
"	"	"	"	"	f2	.32	"	"	"	"	f2	.29
"	"	"	"	"	s1	.10,	"	"	"	"	s1	.38
"	"	"	"	"	s2	.28,	"	"	"	"	s2	.27
Average						.36						.31

The average of the correlation between recall and intelligence with age eliminated or held constant is .36, between recognition and intelligence, .31; between the 30-seconds recall tests and

[2] For full discussion on this method see Yule, G. N., "An Introduction to the Theory of Statistics," Chap. XII; E. L. Thorndike's "Theory of Mental and Social Measurements," p. 182, and T. L. Kelley's "Table to Facilitate the Calculation of Partial Coefficients of Correlation and Regression Equations," *Bulletin of University of Texas,* 1916, No. 27.

intelligence with age constant is .35; between the 24-hours recall test and intelligence with age constant is .36. Intelligence gives an average coefficient of .33 with the 30-seconds recognition test, and .30 with the 24-hours recognition test, when the age factor is eliminated.

The correlations between retention and intelligence, when age has been eliminated or rendered constant, are the most accurate statements, in terms of raw coefficients, that may be secured. The correlations between age and retention in the groups used are so small, however, as to produce but slight difference from the figures previously discussed in which age was not eliminated.

5. Summary

The results of the present investigation lead to the following conclusions: (1) The correlation between general intelligence and retention is positive and in some cases fairly high. (2) This degree of correlation varies with the materials to be retained. Among the four kinds of material used retention of pictures correlates highest with the measure of intelligence employed, then come retention of words, retention of syllables, and retention of forms. (3) This degree of correlation varies with the interval of retention. On the whole, the measure of intelligence employed correlates higher with immediate rather than with delayed memory. (4) This degree of correlation varies with the methods of testing retention. Recall of pictures, words and forms, has a slightly higher correlation with intelligence than does recognition of these kinds of material. On the contrary, recall of syllables has a lower correlation with intelligence than does recognition. (5) The correlation between retention and age differs greatly with the kinds of material to be retained. The recall of pictures gives the highest correlation, and the recall of words gives the second. On the whole, recall correlates higher with age than does recognition. The correlations between age and recognition tests in most cases are negative, and the positive correlations are very low.

6. Review of Past Studies on Relationship Between General Intelligence and Memory

Although most of the past experimental studies on the relationship between general intelligence and retention are subject to one sort or another of the objections stated at the beginning of this chapter, a brief review of the methods used and the conclusions reached cannot fail to be suggestive.

Wissler [3] used digits and passages as memory tests in his study of the correlation of mental and physical traits for about 250 Columbia freshmen and some seniors. Eight digits form one series. This is presented either auditorily or visually at a rate of about two per second, after which the subjects write from memory. A passage containing 100 words is used as a test of logical memory, by the auditory method. The correlation thus found between average college standing and logical memory for 86 cases is .19. The correlation between auditory memory of position and average college standing for 121 cases is .10. The correlation between logical memory and arithmetic is .11; and between logical memory and Latin is .22.

Burt [4] tested the memory of two groups of children from two Oxford schools and had estimates made of their general intelligence. One of these groups consisted of 13 boys attending a superior elementary school, whose parents were of the "lower middle class." The other consisted of 30 boys attending a higher class preparatory school, who were sons of "eminent men in the intellectual world." The age of the boys was between twelve and a half and thirteen and a half years. Sixty monosyllabic words—30 of concrete significance and 30 of abstract—and 30 nonsense syllables, were used as a memory test. The intelligence standing was based upon estimates of headmasters, teachers and school fellows, and rank in examinations in literary and mathematical subjects. The memory tests were presented visually and the boys pronounced them orally. Then they were requested

[3] Wissler, Clark. The Correlation of Mental and Physical Traits. *Psychological Monograph*, 3:1901, No. 6, p. 35 ff.

[4] Burt, Cyril. Experimental Tests of General Intelligence. *British J. of Psychol.*, 3:1919, pp. 94–174.

to write as many as they could remember. The coefficient of correlation between the amalgamated series of memory tests and the headmaster's rank order of intelligence is .67 for the elementary school group, and .78 for the preparatory school group. The correlation between the amalgamated memory tests and the examination rank order (for literary and mathematical subjects) is .67 for the elementary, and .82 and .69 for the preparatory.

Brown[5] measured delayed memory and its correlation with other mental abilities. He had two groups of subjects, one of 114 adults, and the other 145 children between the ages of eleven and twelve. However, only the results of part of the subjects were obtainable, since the memory tests were given to only a few of the adult group. Syllables and poetry were used as test material. Ten syllables were presented for study for from 2 to 3 minutes (the results of those who studied the test for less than 3 minutes were excluded from statistical treatment), and retention was tested after a 24-hours interval. Three verses of Hood's "Queen Mab" were studied for about the same length of time, and retention tested after the same length of interval. "Separate and independent grading by different teachers" was used as the measure of intelligence. In addition to this, school marks were also used. The group of children was divided into three groups of about 50 each in the statistical treatment. The coefficients of correlation between memory and other mental abilities for each group are quoted in Table VII (Group IV, 30 adults).

Wyatt[6] covered both immediate memory and retention after an interval of two days. The material used was nonsense syllables. The estimation of general intelligence was done in the following manner: "A classification of the children according to the order of their intelligence was obtained from the master in charge of the class. This classification was based not upon the results of any class examinations, but upon the master's

[5] Brown, W. Some Experimental Results in the Correlation of Mental Abilities. *British J. of Psychol.*, 3:1919, pp. 296–322.

[6] Wyatt, S. The Quantitative Investigation of Higher Mental Processes. *British J. of Psychol.*, 6:1913, pp. 109–133.

opinion of the intellectual capacities of each of the children." The number of his subjects is rather small, being 34 children between the age of 11 and 13. A series of 10 syllables was studied for three minutes. Immediately after that the subjects were asked to reproduce as many as they could remember. The reproduction test was repeated after a two-days interval. The coefficients of correlation between the estimated intelligence and

TABLE VII *

	School Mark	Gen. Int.	e.r.	a.n.o.s.	Ebbing-haus' Test	Add. Accuracy	Add. Speed
Group I							
Memory digits ..	...	...	.40	.29	.52	.26	.31
Poetry	...	...	.27	.28	.52	.41	.38
Group II							
Memory digits ..	.59	.55	.37	...	...	—.23	—.10
Group III							
Memory digits ..	.40	.09	.00	.00	.28	.00	.00
Poetry	.60	.57	.23	.14	.44	—.11	.00
Group IV							
Memory digits ..	...	...	...	...	.31	.20	.18

* e.r., a.n.o.s. are cancellation tests.

immediate reproduction is .59, and between intelligence and delayed reproduction is .74.

With regard to the difference in magnitude of the two coefficients, Wyatt concludes that ". . . intellectual capacities are more concerned in prolonged retention than in immediate recall. It is reasonable to assume that a longer interval between learning of the series and then recall would give even a higher correlation with intelligence." From the data of the present experiments on recall of syllables and in both recall and recognition of other kinds of material there are evidences leading to a contrary statement.

Wyatt included in his memory test also the letter square test. Twelve consonants of the alphabet were presented for a 25-seconds period of study. Then the subjects were requested to write immediately from memory these letters in the position they were presented. The coefficients between this test and estimated intelligence is .18 (P. E. .11). Wyatt considers this memory test as being unsuccessful on the ground that the process of imagery is relatively prominent.

Simpson [7] made an extensive study of tests of specific mental functions, which would be correlated closely with general ability and could, therefore, be used as symptomatic measures of general intelligence. His subjects were of two distinct groups, one representing the high end and the other the low end of the intelligence scale. Seventeen individuals formed the first group and 20 the second. These individuals were rated in order of merit for general intelligence by several persons. In the case of the good group the judges were fellow subjects of the group. The coefficient between estimated intelligence and memory for words is .93, and between estimated intelligence and memory for passages, .35.

Starch [8] measured a group of 15 high school pupils with a series of eight tests. Among these were memory for words and memory for passages. At the close of the tests each of the 15 pupils was asked to give a rating to the other 14, ranking the one that was estimated to have the highest intelligence as 1, and so on down to the 14th. The coefficients of correlation between the estimated intelligence and memory for words is .53, and between estimated intelligence and memory for passages is .56.

Concerning memory and intelligence Meumann [9] says that the quantity of material reproduced is not in itself a reliable index of intelligence, yet the average results of mass experiments will always show that the more intelligent subject has the better memory efficiency.

Several other investigators studied the group differences in memory. Binet [10] contrasted 6 dull and 5 bright boys, and found that, on the whole, the latter surpassed the former in memory. Cohn and Dieffenbacher [11] divided their subjects into two groups, the "better and poorer intellectually." The former excelled the latter in the memory tests in 11 of his 14 groups. The superiority

[7] Simpson, B. R. Correlation of Mental Abilities. *Columbia University Contributions to Education*, No. 53, 1912.

[8] Starch, D. *Educational Psychology*, 1915.

[9] Meumann, E. The Psychology of Learning, 1913, p. 393.

[10] Binet, A. Attention et Adaptation. *Année Psychol.*, 6:1899 (1900), pp. 248–404.

[11] Cohn, J., und Dieffenbacher. Untersuchungen über Geschlechts, Alters- und Begabungs-Unterscheide bei Schulern. *Beihefte zur Zsch. f. Angew Psychol.*, No. 2, 1911, pp. 213.

amounted to about 10 per cent, and turned out to be less in the higher than in the lower school grades. Lapie [12] contrasted "pedagogically advanced" and "pedagogically retarded" pupils, and concluded that these groups differ little in retentive power as

TABLE VIII

Coefficient of Correlation of Teachers' Estimates with

	Immediate recall nonsense	Immediate recall sense	Delayed recall nonsense	Delayed recall sense	Percentage retained nonsense	Percentage retained sense
8th Grade	+0.55 P.E. 0.07	+0.55 P.E. 0.07	+0.44 P.E. 0.08	+0.50 P.E. 0.08	+0.43 P.E. 0.09	+0.45 P.E. 0.09
6th Grade	+0.60 P.E. 0.07	+0.54 P.E. 0.08	+0.57 P.E. 0.07	+0.56 P.E. 0.07	+0.40 P.E. 0.09	+0.50 P.E. 0.08
5th Grade	.....	+0.53 P.E. 0.08		+0.59 P.E. 0.07		+0.48 P.E. 0.08
4th Grade	+0.14 P.E. 0.10	+0.28 P.E. 0.09	+0.30 P.E. 0.09	+0.19 P.E. 0.10	+0.21 P.E. 0.10	+0.28 P.E. 0.09
3rd Grade	.....	+0.48 P.E. 0.08		+0.50 P.E. 0.08		+0.48 P.E. 0.08
Average	+0.43	+0.48	+0.44	+0.47	+0.35	+0.44

such, but the retarded pupils frequently reproduced the material in bizarre and contradictory combinations, *e.g.*, as in speaking of "a young person fifty-four years old." Smedley [13] declares that "the parallelism between school standing and memory power holds good throughout school life."

The correlation between teachers' estimates of general intelligence and immediate and delayed recall (an interval of 3 to 4 hours being used) has been studied by Gates.[14] Nonsense syllables and connected sense material in the form of biographies were used. The time of study was kept constant while the amount of material to be retained was varied, so that the ablest subjects could recall immediately from 70 to 90 per cent of it. The results of Dr. Gates' study are quoted in Table VIII.

Another source of information concerning the relation between memory and intelligence is found in the results of experimental studies of mental abilities of the feebleminded. Abelson [15] tested

[12] Lapie, P. Avances et retardes. *Année Psychol.*, 18:1912, pp. 233–270.

[13] Smedley, F. Report Dept. Child-Study and Pedagogic Investigation (Chicago Public Schools), No. 3, 1900–1901.

[14] Gates, Arthur I. Correlation Between Immediate and Delayed Recall. *J. of Educational Psychol.*, Vol. IX, No. 9, Nov., 1918.

[15] Abelson, A. R. The Measurement of Mental Ability of Backward Children. *British J. of Psychol.*, 4:1911, pp. 268–314.

88 girls and 43 boys in eight of the London County Schools for Defectives. He found the correlations to be .18 and .19 between memory for names and imputed practical intelligence (competence to perform errands), but the correlations with school performance were higher (.20 and .24 with "estimated ability in reading" and .30 and .32 with "estimated ability in arithmetic," for the girl group and the boy group respectively). Norsworthy [16] compared 159 normal and 68 feebleminded children in respect to memory for related words and unrelated words, and found that only 5 per cent of the feebleminded do as well with the related words and only 6 per cent do as well with the unrelated words as do 50 per cent of the normal children. Galton [17] applied a memory span test to imbeciles, and found that most subjects of this type failed to repeat more than four digits, while several imbeciles showed remarkable memories for dates and passages in books. Johnson [18] selected subjects of the so-called school case group and found that their average span for digits is 5.3, which is approximately 1.3 digits less than the normal span of an eight-year child. Smith [19] found that in the auditory letter span test the epileptics are generally inferior to normal subjects, and in particular, that they make nearly three times as many errors of insertion. Smedley [20] states that "the boys of the John Worthy School (incorrigibles, defectives, truants, etc.) are lower in memory power than are the pupils of the other schools, and this disparity increases with age."

It is interesting to note what diversified opinions are represented in the concluding statements of the different experiments reviewed above with regard to the relation between general intelligence and

[16] Norsworthy, Naomi. The Psychology of Mentally Deficient Children, 1906, p. 238.

[17] Galton, F. Supplementary Notes on "Prehension" in Idiots. *Mind*, 12:1887, 79–82.

[18] Johnson, G. E. Contribution to the Psychology and Pedagogy of Feeble-Minded Children. *Ped. Sem.*, 3:1895, pp. 245–301.

[19] Smith, W. G. A Comparison of Some Mental and Physical Tests in Their Relation to Epileptic and to Normal Subjects. *British J. of Psychol.*, 1:1905, pp. 240–260.

[20] Smedley, F. Report Dept. Child-Study and Pedagogic Investigation (Chicago Public Schools), No. 3, 1900–1901.

retention. Wissler, for example, seems to have denied a relation between general intelligence and immediate memory. On the contrary, Burt and Simpson assert a high correlation between the two. The truth would seem to lie between the two extremes. Wissler, although testing a large number of subjects, took fifty minutes only for fifteen tests. The results, therefore, should not be accepted at their face value, since it has been argued by Simpson [21] that the coefficients of correlation of Wissler's investigation would have gone considerably higher if chance inaccuracies were corrected for attenuation. Burt and Simpson both experimented in two distinct groups, the intelligent and the unintelligent, or the bright and the dull. This uneven distribution of intelligence of the subjects tends to heighten the correlation. Dr. Gates' coefficients of correlation between teachers' estimates and recall of sense material are about as high as the results of the present investigation would suggest, although the coefficients between teachers' estimates and recall of nonsense material are generally higher.

[21] Simpson, B. R. Correlation of Mental Abilities. *Columbia University Contribution to Education,* No. 53, 1912, p. 75.

CHAPTER V.

CORRELATIONS BETWEEN IMMEDIATE AND DELAYED RETENTION TESTS AND THE AMOUNT OF FORGETTING

1. The Correlation Between Immediate and Delayed Recall, and the Correlation Between Immediate and Delayed Recognition

Correlations between scores on the immediate and delayed tests confirm the results of earlier studies that there is a considerable positive correlation between immediate and delayed memory, tested by both the methods, recall and recognition. The correlations between the 24-hours retention tests and the relearning tests were also computed. These coefficients are presented in Table IX.

TABLE IX

Coefficients of correlation between the 30-seconds and the 24-hours retention tests, and between the relearning test and the 24-hours retention test. p = picture; w = word; f = form; s = syllable; 1 = 30-seconds retention test; 2 = 24-hours retention test; 3 = relearning test.

	Recall	Recognition
p1 with p2	.60	.65
w1 " w2	.53	.40
f1 " f2	.49	.41
s1 " s2	.27	.21
p3 " p2	.46	.66
w3 " w2	.61	.51
f3 " f2	.41	.30
s3 " s2	.28	.14

Between tests of immediate and delayed recall, the average of the coefficients is .47 as compared to .42, the average of the coefficients for the recognition tests. The difference between these averages is too small to be significant. Between the scores on the test of delayed recall, and the relearning test which followed it, the average of the correlations for the four kinds of material is .44; in the case of recognition the average is .40. The difference between these averages is again too small to be significant.

While the two formal functions, recall and recognition, show

a very similar central tendency, the sizes of the correlations are greatly influenced by the character of the material. The average of the eight correlations between immediate and delayed recall is .46, and that of the eight correlations between immediate and delayed recognition is .42. The average of the four correlations between immediate and delayed recall of pictures and of words plus the four correlations between immediate and delayed recog-

TABLE X

Correlations between the 30-seconds retention test and the relearning test. p = picture; w = word; f = form; s = syllables; 1 = 30-seconds retention test; 3 = relearning test.

			Recall	Recognition
p1	with	p3	.60	.52
w1	"	w3	.62	.43
f1	"	f3	.32	.37
s1	"	s3	.23	.37

nition of pictures and of words is .56; while the average of the four correlations between immediate and delayed recall of forms and of syllables plus the four correlations between immediate and delayed recognition of forms and of syllables is .31.

The very low correlations found for syllables is doubtless largely caused by the relatively large number of zero scores in the 24-hour retention tests. In other investigations, in which a longer study period was given, thus providing a better distribution of scores in the retention tests, much higher correlations have been found.[1]

2. The Correlation Between the 30-Seconds Retention Test and the Relearning Test

The method and procedure in giving the relearning test and the length of the interval were similar to those of the 30-seconds retention test. The dominating purpose in giving the relearning test was to check up the results of the 30-seconds retention test. To accomplish this, correlations between scores on the two tests were computed. The results are given in Table X.

The two tendencies found in the correlations between immediate and delayed recall and immediate and delayed recognition are

[1] Gates, Arthur I. Correlations Between Immediate and Delayed Recall. *Journal of Educational Psychology,* Vol. IX, No. 9, November, 1918.

shared by the correlations between the 30-seconds test and the relearning test.

Both in recall and in recognition the coefficients for pictures and words are higher than those for forms and syllables. In these cases, there are insufficient undistributed scores in the tests with nonsense syllables to account for the low correlations found. It appears, therefore, that under the conditions of the present experiment nonsense syllables and geometrical forms are less reliable test materials than words and pictures.

3. *The Amount of Forgetting*

The amount of forgetting during a 24-hour interval is seen in the differences between the average scores on the 30-seconds retention test and those on the 24-hours retention test. These differences, both absolute and in terms of per cent, are given in Table XI. However, since the average is merely a measure of

TABLE XI

Differences between the average scores on the 30-seconds retention test and the average scores on the 24-hours retention test. p=picture; w=word; f=form; s=syllable; 1=30-seconds retention test; 2=24-hours retention test.

Tests	Recognition			Recall		
	Average Scores	Differences		Average Scores	Differences	
		Absolute	Per Cent		Absolute	Per Cent.
p1	32.2			12.4		
p2	22.9	9.3	28.9	7.4	5.0	42.0
w1	31.2			9.6		
w2	16.7	14.5	46.8	4.5	5.1	53.1
f1	10.7			5.1		
f2	7.2	3.5	32.7	4.0	1.1	20.0
s1	13.8			3.6		
s2	4.9	8.9	64.5	1.5	2.1	60.0

central tendency, the difference between the average score on the 30-seconds retention test and the average score on the 24-hours retention test gives only a suggestion of the amount of forgetting.

In the case of recognition, the average amounts of decrease in the scores are as follows: For pictures, 28.9 per cent; for words, 46.8 per cent; for geometrical forms, 32.7 per cent, and for nonsense syllables, 64.5 per cent. In the case of recall, the losses

due to disuse are as follows: For pictures, 42.0 per cent; for words, 53.1 per cent; for forms, 20.0 per cent, and for syllables, 60.0 per cent. According to these data, words and syllables are less permanently learned, under the conditions of the experiment, than pictures and forms.

The most satisfactory notion of the amount of forgetting is obtained by a study of the overlapping of the graphs of distribution of scores of the immediate (the 30-seconds-test) and the 24-hour retention tests. These pictures are shown in Figures I to VIII.

By computing the percentage of cases in the retention test which equal or exceed the median score for the immediate test, another rough measure of the loss due to disuse is obtained. These results are given in Table XII.

TABLE XII

Per cent of scores on the 24-hours retention test, equaling or exceeding the median of the total number of scores on the 30-seconds retention test. p=picture; w=word; f=form; s=syllables. 1=30-seconds retention test; 2=24-hours retention test; 3=relearning test.

	Recognition	Recall	Average
p2 Equaling or exceeding median of p1	15.0	4.5	9.8
w2 Equaling or exceeding median of w1	5.8	7.1	6.5
f2 Equaling or exceeding median of f1	27.7	26.8	27.3
s2 Equaling or exceeding median of s1	10.6	8.7	9.7

The data of Table XII show, similarly but less impressively than the differences in average scores, a tendency toward better retention of geometrical forms and pictures than of nonsense syllables and words. Except that the geometrical forms are retained relatively well, the differences among the materials are not great. The geometrical forms proved to be comparatively difficult to learn, as the small scores in the immediate tests show. The subjects apparently learned more thoroughly a smaller number, and, because of the greater degree of overlearning, were able to recall or recognize a larger proportion after 24 hours of disuse.

CHAPTER VI

CORRELATIONS BETWEEN RECALL AND RECOGNITION

Memory has long been a favorite subject of study in experimental psychology. The two methods of testing memory, reproduction and recognition, were distinguished by Wolfe in 1886.[1] Ever since they have been used in many experimental studies. It was found that the strength of retention varies not only with different kinds of material, but also with different methods of testing. On this point Achilles in her "Experimental Studies in Recall and Recognition" concludes as follows: "The data indicate that a person who recalls material well may recognize that kind of material well, fairly well, or poorly—we know little about one's recognition memory from a test of recall." [2]

The question whether or not there is a fundamental difference, that is, a difference in mechanism, between recall and recognition has been a point of dispute among psychologists. While unanimously accepting association as the mechanism of recall, they differ in opinion regarding the mechanism of recognition.[3] The first opinion was offered by Müller and Heine, who used as the basis of their argument the difference in the susceptibility of recall and recognition to the influence of retroactive inhibition. From the results of an experiment Heine concluded thus: "Retroactive inhibition does not affect the basis of recall. The basis of recognition must, therefore, differ from that of recall, and since recall is based on association, recognition must be based on something else." In a preliminary report of the same experiments[4] Müller

[1] Wolfe, H. K. Untersuch. über d. Tongedächtniss. *Phil. Stud.*, Vol. III, 1886.

[2] Achilles, E. M. *Archives of Psychology*, No. 44, September, 1920, p. 74.

[3] Woodworth and Poffenberger. *Experimental Psychology.* Chapter on Recognition Method of Study Memory, especially pp. 112–116 (procurable only in mimeographed form).

[4] *Kong. f. exper. Psychol.*, 1912, p. 218.

also says: "It is found then that retroactive inhibition is in evidence when we are concerned with the efficiency of associations . . . but not when recognition is tested." From this we infer that the recognition examined in these experiments is not based on the efficiency of associations. We must, therefore, distinguish two sorts of fixation: one which makes possible the recognition here studied, and one which provides associative connections."

This theory has been criticized by Woodworth and Poffenberger on the ground that careful analysis of some of the results of Heine's own experiments, and the data furnished by Strong[5] show that retroactive inhibition certainly affects recognition, though to a less degree than it does recall. This quantitative difference is explainable by the all around superior efficiency of recognition as compared with recall.

Achilles explains the difference between recall and recognition in terms of the height of the threshold of memory. She says: "Thus the two processes, recall and recognition, should not be thought of as in opposition or methods whose scores differ by a gap. The difference in our memory is one of degree—the item may be easily recalled, recalled with difficulty, easily recognized, recognized with difficulty. The difference may be expressed as a difference in the distance above the lower threshold of memory. How short the distance seems when a word 'we cannot just recall' is mentioned, and we instantly say 'that is it' when we hear it!" Achilles thus believes that recall and recognition form a continuum—the one merges with the other.

The magnitude of the coefficients of correlation between recall and recognition may throw some light on the character of the two functions. The correlations are given in Table XIII.

These coefficients are generally small in magnitude. They vary with different lengths of interval and with different kinds of material. On the whole there is a tendency for the correlations to be higher for materials rich in associations than those for materials devoid of or meager in associations. The highest coef-

[5] Strong, E. K., Jr. Articles on Recognition Memory in *Psychol. Rev.*, Vol. XIX, 1912.

TABLE XIII

Coefficients of correlation between recall and recognition. p = picture; w = word; f = form; s = syllable; 1 = 30-seconds retention test; 2 = 24-hours retention test; 3 = relearning test.

Recall	p1	with	Recognition	p1	.20
"	p2	"	"	p2	.11
"	p3	"	"	p3	.13
			Average		.15
Recall	w1	with	Recognition	w1	.30
"	w2	"	"	w2	.25
"	w3	"	"	w3	.09
			Average		.21
Recall	f1	with	Recognition	f1	.12
"	f2	"	"	f2	.03
"	f3	"	"	f3	.15
			Average		.10
Recall	s1	with	Recognition	s1	.08
"	s2	"	"	s2	.06
"	s3	"	"	s3	.02
			Average		.05

ficient is .30 for words in the 30-seconds retention test. The lowest is .02 for syllables in the relearning test. The average coefficient in all three retention tests for words is .21; for pictures, .15; for forms, .10, and for syllables, .05. There is also a general tendency for the correlations in the 30-seconds retention test to be higher than those in the 24-hours retention test; and these higher than those in the relearning test. The average coefficient of the four kinds of material in the 30-seconds retention test is .18; in the 24-hours retention test is .11, and in the relearning test is .10.

The correlations between recall and recognition are very small in comparison with the correlations between the various recall tests and in comparison with the various recognition tests. The average of the twelve tests of recall (*i.e.*, p1 with p2, etc.; p1 with p3, etc., and p2 with p3, etc.) is .45, and the average of twelve similar tests of recognition is .42, whereas the average of the correlations between recall and recognition (from Table XIV) is .13. The implication of these data is that recognition and recall, while positively associated, are, nevertheless, distinct in important respects. They can scarcely be treated as identical processes, at different levels with reference to a threshold of retention.

CHAPTER VII

CORRELATIONS DETERMINED BY THE FORM OF THE FUNCTION COMPARED WITH CORRELATIONS DETERMINED BY THE CONTENT USED

In the foregoing chapter we considered the correlations between recall and recognition of the same kinds of material. In this chapter we shall attempt to compare these correlations with the correlations between recall of different kinds of material, and between recognition of different kinds of material. Correlations of the latter category are determined by the form of the function, while those of the former are determined by the content of the test. The differences between them indicate whether the form of the function or the content used is the more influential factor.

Correlations between recall of different kinds of material are shown in Tables XIVa and XIVb:

TABLE XIVa

Coefficients of correlation between recall of different kinds of material after 30 seconds. p=picture, w=word, f=form, s=syllable.

	P_1	W_1	F_1	S_1
P_1		.58	.16	.17
W_1	.58		—.10	.41
F_1	.16	—.10		.05
S_1	.17	.41	.05	
Average	.30	.30	.03	.21

TABLE XIVb

Coefficients of correlation between recall of different kinds of material after 24 hours.

	P_2	W_2	F_2	S_2
P_2		.36	.18	.31
W_2	.36		.29	.36
F_2	.18	.29		.15
S_2	.31	.36	.15	
Average	.28	.33	.21	.27

TABLE XVa

Coefficients of correlation between recognition of different kinds of material after 30-seconds interval. p=picture, w=word, f=form, s=syllable.

	P_1	W_1	F_1	S_1
P_1		.33	.31	.32
W_1	.33		.17	.36
F_1	.31	.17		.15
S_1	.32	.36	.15	
Average	.32	.29	.21	.28

TABLE XVb

Coefficients of correlation between recognition of different kinds of material after 24-hours interval.

	P_2	W_2	F_2	S_2
P_2		.27	.39	.12
W_2	.27		.02	.22
F_2	.39	.02		.10
S_2	.12	.22	.10	
Average	.26	.17	.17	.15

The average of the correlations between recall of different materials, in the immediate retention test, is .21. The average of the correlations for the recall tests after 24 hours is .27. The corresponding averages for recognition are .27 and .19. The average of these four average coefficients is .23.

The average of the correlation between recall and recognition of the same kind of materials in the immediate retention test is .18 and in the 24-hour retention test .11. The average of the two is .145.

The form of the function, then, appears to contribute more toward positive correlations than the content acted upon, in the comparisons provided by the present investigation. Achilles' [1] results, in the main, are in harmony with the present findings.

Differences in contents used cause less fluctuation in people's retentive efficiency than difference in methods of testing it. We can predict with a greater degree of accuracy a person's recall memory or recognition memory for a certain kind of material by a test of recall or recognition for another kind of material than we can predict recall memory for certain kinds of material by a test of recognition, even for the same kind of material, or

[1] Achilles, E. M. Experimental Studies in Recall and Recognition, pp. 42–44.

his recognition memory by a test of recall, even for the same kind of material. This discussion, however, is only of theoretical interest. For practical purposes, since the correlations are generally low, the prediction in either case could not be of much value.

The Hierarchy of Correlations as Determined by the Material Used

Since the two functions, recall and recognition, were kept constant, as well as the time of the tests and the number of items used in each test, by arranging the coefficients of correlation in a table according to average magnitude, some notion of the degree to which the several materials involve common psychological elements may be secured. In Table XVI the individual correlations are given, together with the average of four coefficients obtained from the 30-second and the 24-hour recall tests, and from the 30-second and the 24-hour recognition tests.

TABLE XVI

Intercorrelations between recall of different kinds of material, and between recognition of different kinds of material, and their averages in order of magnitude.

	Recall		Recognition		Average
	After 30 sec.	After 24 hrs.	After 30 sec.	After 24 hrs.	
Words-Pictures	.58	.36	.33	.27	.39
Words-Syllables	.41	.36	.36	.22	.34
Pictures-Forms	.16	.18	.31	.39	.26
Pictures-Syllables	.17	.31	.32	.12	.23
Forms-Syllables	.05	.15	.15	.10	.11
Words-Forms	—.10	.29	.17	.02	.10

The average correlations range from .39 to .10. The highest coefficient is found between words and pictures, in which the apparent common factors are familiarity or richness of associations, and the use of verbal responses in indicating the items. Next comes the correlation between words and nonsense syllables, in which the common elements are letters. Next come pictures and forms, obviously alike only in being picture-like drawings. Between pictures and syllables, forms and syllables, and words and forms, the correlations are relatively low.

This hierarchy is probably not a very stable or significant one,

except with respect to the extremes. Words and pictures, and words and nonsense syllables, are pairs with obviously common factors, familiarity, meaning, and the ease of utilizing verbal methods of identification. The correlations are here both above .30. At the other extreme, forms and syllables, and words and forms, have no very obvious identities. The correlations are but .10. These differences, however, may be partly explained by differences in the reliability of the tests.

Retention of What Material Gives the Highest Correlation with Retention of All Others

The several correlations for the 30-second retention test and the 24-hour retention test, as shown in Tables XIV, a b, XV, a b, are averaged in Table XVII. To secure a general measure of recall or of recognition, words and pictures are the best, and about equally useful, materials. Geometrical forms yield particularly low correlations with other materials, in the average.

TABLE XVII

Average coefficients of correlation between recall or recognition of one kind of material and recall or recognition of the other three kinds.

	Recall	Recognition	Recall and Recognition
Pictures with other three kinds of material	.29	.29	.29
Words with other three kinds of material	.35	.23	.29
Forms with other three kinds of material	.10	.19	.15
Syllables with other three kinds of material	.24	.22	.23

The average correlation, at the highest, is very low. This is partly due to the unreliability of tests of the length here used, and partly due to the fact that memory, either as recall or recognition, is not a unitary or compact ability, faculty or power, but a group of particular abilities. In learning one kind of material, a complex of methods of attacks is involved; in learning another kind of material, some of the same, but many new abilities and methods of attack, are utilized. Memorizing may range from mere repetition of a mechanical sort to a highly analytical attack with many of the elements of reasoning. It varies not only from person to person, but it varies, for the same individual, with the

kind of material used, and the purpose which the subject has in mind in learning. Thus there are great variations, both when the function (such as recall or recognition) is kept constant as a means of test while the material is changed, and when the material is kept constant but the form of test is changed. With both kept constant, individual caprice in methods of attack will cause variability of permanence. Memorizing, in sum, is a broad and variable process; indeed, it is nearly as broad as the general term learning.

CHAPTER VIII

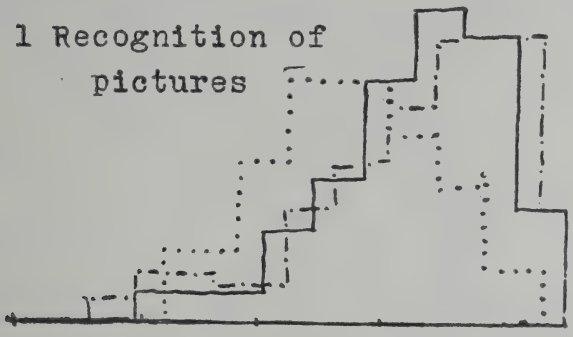
GRAPHS ILLUSTRATING RESULTS

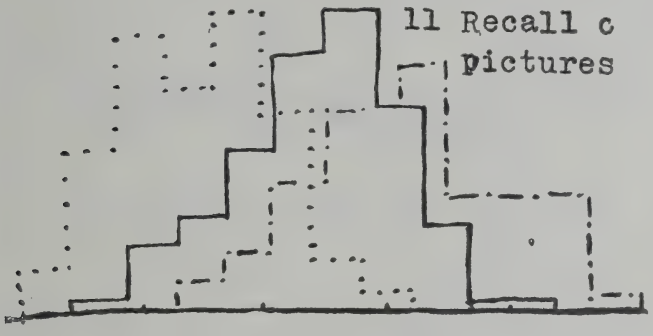
Distribution of Scores on Retention Tests

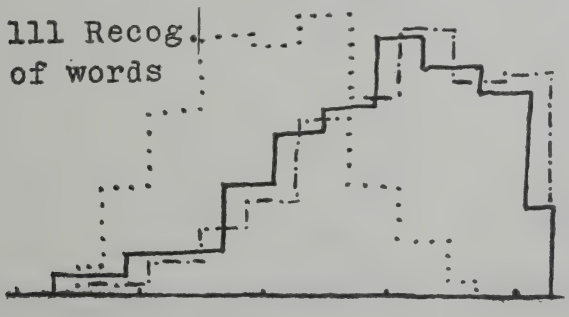
_____ = Initial 30 Sec.Test

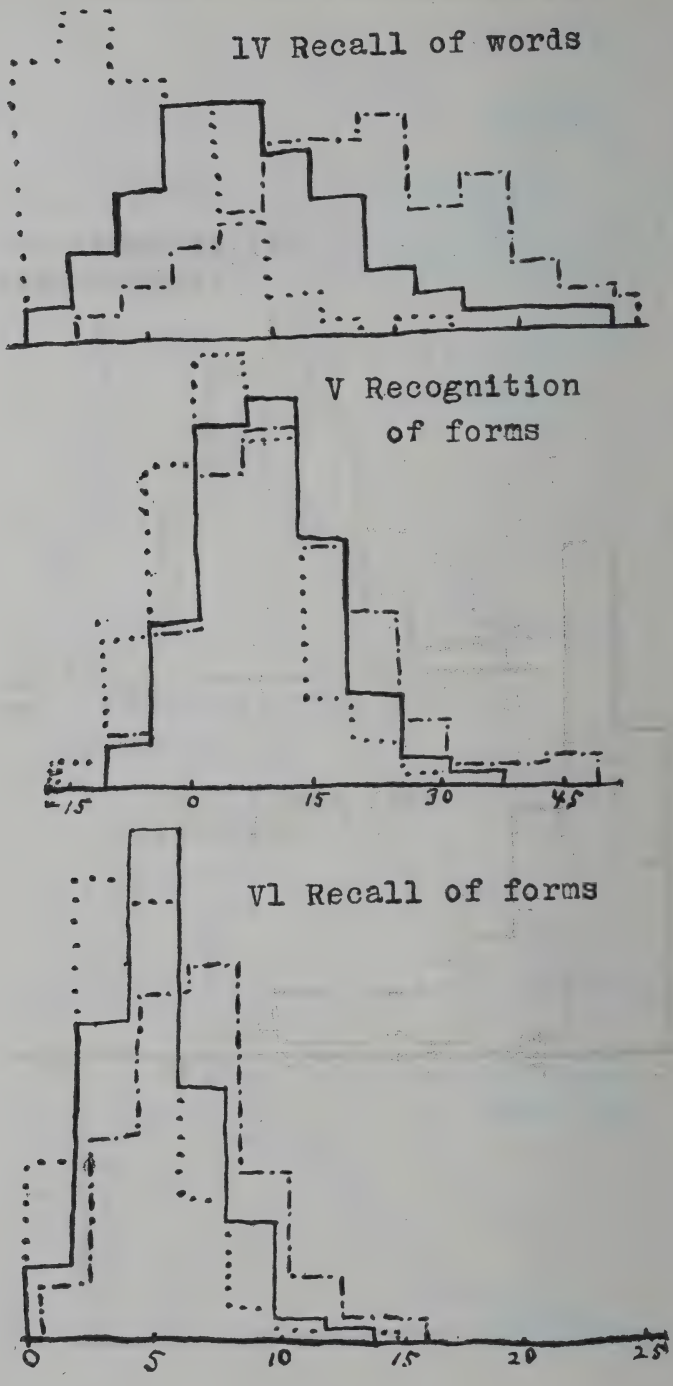
..... = 24 hours Test

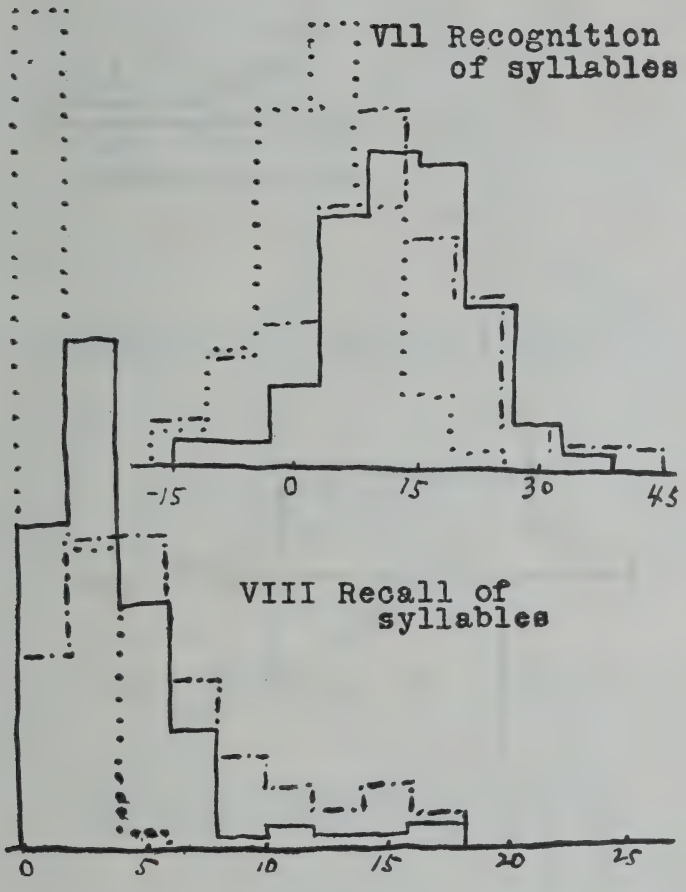
-.-.- = Final 30 Sec. Test

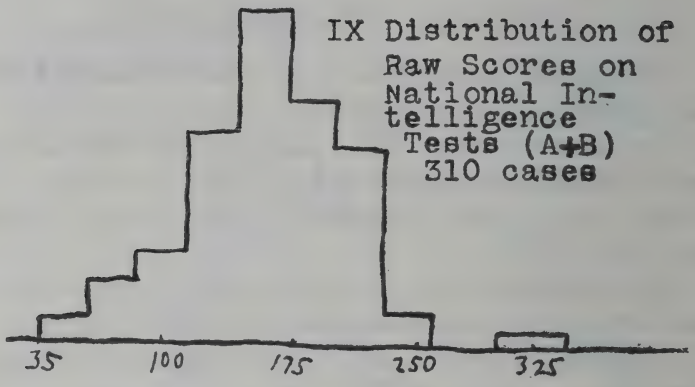




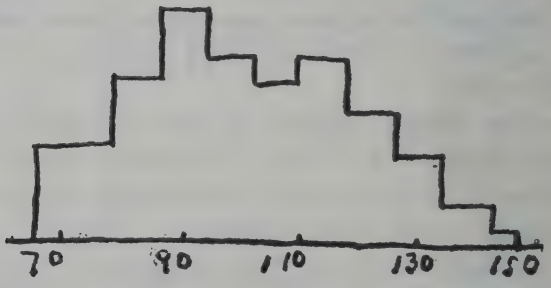



IV Recall of words
V Recognition of forms
-15
0
15
30
45
VI Recall of forms
0
5
10
15
20
25


VII Recognition
of syllables
-15
0
15
30
45
VIII Recall of
syllables
0
5
10
15
20
25



IX Distribution of Raw Scores on National Intelligence Tests (A+B) 310 cases



X Distribution of mental indices 310 cases

CHAPTER IX

SUMMARY AND CONCLUSIONS

1. The present investigation is primarily concerned with a study of retention and its relation to intelligence.

2. The subjects whose scores were treated statistically numbered 310, half of whom belonged to Public School No. 23, and the other half to Public School No. 188 of lower Manhattan, New York City.

3. The composite score on forms A and B of National Intelligence Tests was used as a measure of general intelligence.

4. Retention of four kinds of material, pictures of familiar objects, simple nouns, geometrical forms, and nonsense syllables was tested by both the method of recall and the method of recognition. The correlations between scores on both recall and recognition tests for the four kinds of material, and between these scores and the measure of intelligence were also computed.

5. The correlations between general intelligence and retention with the age factor eliminated were obtained by the partial correlation method.

6. Retention during intervals of varying lengths, one of 30 seconds and the other of 24 hours, was tested, and the correlation between these retention tests and between each of these tests and the intelligence measure was computed.

7. A comparative study was made to ascertain the intercorrelations between the various kinds of retention material employed.

8. The amount of forgetting during 24 hours was estimated by the difference between the average scores on the 30-seconds retention test and the average score on the 24-hours retention test; and also by the per cent of scores on the 24-hour retention test, equaling or exceeding the median score on the 30-seconds retention test.

The chief results of the study may be summarized as follows:

1. The correlations between the measure of intelligence and retention are all positive, and in some cases fairly high.

2. The degree of correlation varies with the materials to be retained. Among the four kinds of material used, retention of pictures of familiar objects correlates highest with the measure of abstract or verbal intelligence; then comes retention of words, retention of syllables, and retention of forms.

3. The degree of correlation varies with the interval of retention. On the whole, the measure of intelligence correlates higher with immediate memory rather than with delayed.

4. The degree of correlation varies with the method of testing retention. Recall of pictures, words, and forms has a slightly higher correlation with the measure of intelligence than has recognition. On the contrary, recognition of syllables has a slightly higher correlation with the measure of intelligence than does recall.

5. The correlation between retention and age differs greatly with the kinds of material to be retained. The recall of pictures gives the highest correlation, and the recall of words the second highest. On the whole, recall correlates higher with age than does recognition. The correlations between age and recognition tests in most cases are slightly negative, and the positive correlations are very low.

6. The correlations between recall and recognition, though positive, are very low, and in some cases practically zero, while both the average of the intercorrelations between the twelve recall tests and the average of the intercorrelations between the twelve recognition tests are fairly high. Thus the data indicate that the two functions, while positively associated, are, nevertheless, distinct in important respects. They can scarcely be treated as identical processes, at different levels, with reference to a threshold of retention.

7. A comparative study of correlations between recall and recognition of the same kind of materials with the correlations between recall of different materials and the correlation between recognition of different materials leads to the conclusion that the form of the function contributes more toward positive correlation

than the content acted upon. In other words, we can predict with a greater degree of accuracy a person's recall memory or recognition memory for a certain kind of material by a test of recall or recognition for certain other kinds of material than we can predict recall memory for certain kinds of material by a test of recognition even for the same kind of material, or his recognition memory by a test of recognition even for the same kind of material.

8. The correlations between the retention test after a 30-seconds interval and the retention test after a 24-hours interval are fairly high. On the whole, meaningful and familiar material give higher correlations than material devoid of or meager in associations.

9. Words and pictures, under the conditions of the present study, give higher average correlations with all other material than do nonsense syllables or geometrical forms.

VOL. XXXIV
NO. 5 PSYCHOLOGICAL REVIEW PUBLICATIONS WHOLE NO. 158
1924

Psychological Monographs

EDITED BY

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The Energy Value of the Minimum Visible Chromatic and Achromatic For Different Wave-Lengths of the Spectrum

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PRINCETON, N. J.
AND ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.)
Leipzig (Hospital St., 10); Paris (76, rue de Rennes)

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PREFACE

In the work reported in this dissertation three important determinations have been made at seven points in the spectrum: the minimum visible achromatic and chromatic and the photochromatic interval. For the first time these determinations have been made by direct measurement in absolute energy terms. The investigation is one of a series of studies the object of which has been primarily to lay a foundation for the exact measurement of human responses in terms that are quantitative or numerically comparable. Such work has been possible only within the last few years. The importance of the study as a foundation for the more scientific phases of medical work on the eye should also be noted. Further work on this and other applications of functional testing to the study and diagnosis of diseases of the eye will be carried on by the author in a research position in the Graduate Medical School of the University of Pennsylvania.

The subject of this dissertation was suggested by Professor C. E. Ferree and Dr. G. Rand of the Department of Psychology of Bryn Mawr College and the dissertation was prepared under their direction. The writer wishes to acknowledge her deep indebtedness to Professor Ferree and Dr. Rand for their careful supervision and constant help during the work on the dissertation and for their great kindness and support during the whole of her graduate course. She takes pleasure also in expressing her appreciation to Dr. Rand for her kindness in making the energy measurements given in Table V. Thanks are likewise due to Dr. Luther C. Peter, Associate Professor of Ophthalmology, Philadelphia Polyclinic and College for Graduates in Medicine, University of Pennsylvania, for his courtesy in sending patients for the section on pathological cases.

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I

INTRODUCTION

By the minimum visible is meant the least amount of light radiation to which the eye is capable of giving a visual response. Obviously the term may be used, broadly, to mean the least amount of light of any composition whatever to which the eye gives a just noticeable response; or, narrowly, as the least amount of the wave-length to which the eye is the most sensitive. Apparently the purpose of a recent group of writers has been to favor the narrower usage of the term although it has been variously applied by different members of the group to determinations made with the light of the stars, the light of a tungsten lamp, and to wave-lengths in the mid-region of the spectrum. The broader usage, which is the older, is more compatible with the purpose of this investigation and will be conformed to in the statement and discussion of results. Used in this sense, the minimum visible is synonymous with the absolute threshold or limen.

Numerous points of interest may attach to the determination of the minimum visible.

(1) There may be a scientific curiosity to know the least amount of energy to which the eye is capable of giving a response and to compare this with the least amount to which the ear or some other sense organ gives a noticeable reaction. Wien, for example, was led to attempt a determination of the minimum visible by his previous work on the minimum audible. A natural extension of this interest is a comparison of the sensitivity of the eye with that of the physical instruments which respond to light. Coblentz has found, for example, that it has, roughly speaking, 300,000 times as great a sensitivity to light radiations as the most improved type of thermopile.

(2) In the evolution of the sense organs, many complex characteristics and adaptations have developed presumably in the interests of functional efficiency. The eye, for example, has

developed to a high degree a selectiveness of response to light radiations. Obviously in adapting light to the service of the eye in problems of illumination and in making a correct use of the eye in the many scientific and technical ways in which it is employed, it is highly important, therefore, to know minutely this selectiveness of response both as to kind and amount. It is also interesting from explanatory and technical points of view to be able to compare the sensory with other known and better understood types of response such as the photoelectric, the photochemical, and the thermoelectric reactions, the action of light on selenium, etc. For example, explanatory theories of the eye's response have already been developed in terms of two of these types of reaction—the photochemical and photoelectric—and all of them, including the sensory reaction, have been utilized at various times for rating light intensities for scientific and technical purposes.

(3) It is generally recognized that the most sensitive means of detecting the eye's abnormality due to natural causes or its subnormality due to pathological conditions and processes is in terms of its lack or loss of sensitivity or power to give response, relative and absolute. There are many practical applications of this principle. For example, (a) one of the ways in which ocular fitness for vocational purposes is rated is a determination of the light and color sense. Eyes vary a great deal in light sensitivity, particularly in their range of sensitivity to light intensities. Many, for example, who are able to qualify for work at medium and high intensities of illumination are disqualified for vocations requiring keen power and quickness of vision at low illuminations. Others lack in color sensitivity, varying from a complete absence of power to sense one or more colors to slight deficiencies which disqualify only for work which requires special powers such as great keenness of discrimination, speed of discrimination, etc. And (b) the most pronounced and earliest manifestation of pathological conditions of the sensory mechanism is the loss of light and color sensitivity. This varies from a slight deficiency to a total loss of function, depending upon the severity and stage of advancement of the pathological condition. The application of the testing of light and color sensitivity to

diagnosis, however, is in its infancy, partly because of the lack of instruments and methods which are feasible for office and clinic work and partly because of a lack of knowledge of norms of sensitivity for the healthy eye and of the deviation from these norms which are characteristic of disease and which differentiate one diseased condition from another.

Some of the known effects of pathological conditions are a diminished light sensitivity, a particular and differential manifestation of which is a greatly diminished or entire absence of power to see at low illumination, absolute and partial loss of color sensitivity, changes in the relative sensitivity to the different colors, and changes in the interval between the achromatic and chromatic thresholds of sensitivity to colored lights—the photochromatic interval. As has already been stated, but little use has been made of the testing of light and color sensitivity of the central retina by the medical profession. Their work up to the present time has been confined chiefly to the mapping of the fields of light and color sensitivity. Even this has been almost prohibitive because of the care required to obtain an acceptable precision of result, and the time consumed in making the determinations in a sufficient number of meridians. It is a matter of great interest and importance, therefore, to see how far central sensitivity testing, which with methods amply sensitive for diagnostic work need consume but little time, can be substituted for field taking. As already indicated, field taking is at best a time consuming and difficult performance from the standpoint of the patient, the physician, and the apparatus and controls required.

While the medical aspects of the problem have made the strongest appeal to the writer's personal interests, it has been deemed advisable to subordinate them at this time to an endeavor to build a sounder groundwork on which to rest the applications. It is important in every applied field that there should be standards of reference as to apparatus, methods, and results against which the deviations made in the interests of convenience and feasibility can be checked and evaluated and from which fresh starts can be made.

There are two important aspects of the testing of retinal sensitivity: the testing of the absolute sensitivity to the different

wave-lengths of light and a determination of the comparative or relative sensitivity to these wave-lengths. Differences in both of these regards are fundamental in all of the fields in which sensitivity testing and its results may be applied. To serve as a standard of reference it is obvious that absolute sensitivity should be expressed in absolute terms both with regard to the composition of the stimulus and to its intensity, *i.e.,* for the eye, in terms of wave-length and energy value of light. It is equally obvious that if the sensitivities to the different wave-lengths are to be compared, the intensity values of the stimulus of which sensitivity is taken as the reciprocal must be expressed in terms that are numerically comparable, *i.e.,* in terms of the physical intensity or energy value of the lights employed. Norms either of chromatic or achromatic sensitivity have not as yet been determined in absolute terms. Fragmentary attempts have been made on the basis of results obtained from a few observers to express achromatic sensitivity in relative terms. The investigation of chromatic sensitivity, however, has not progressed even this far. The work of establishing norms of absolute and relative sensitivity for both of these types of response will involve expenditure of a great deal of time and effort and the coöperation of many people. Even to contemplate it seems overambitious at this time. However, every work must start from small beginnings. It has been the purpose of this study to make such a beginning of the study of the thresholds of chromatic and achromatic sensitivity.

The following determinations have been made at seven representative points in the spectrum:

(1) The achromatic threshold.
(2) The chromatic threshold.
(3) The photochromatic interval.

Twenty-one observers have been used in making these determinations and in every case a direct energy measurement was made of the light used to stimulate the eye. In addition, determinations were made in a limited number of pathological cases.

II

HISTORICAL SUMMARY

As early as 1888 Hermann Ebert (1) attempted to ascertain numerically the relative achromatic sensitivity of the eye to wave-length. Two lines of evidence had led him to suppose that the eye might have a maximum of sensitivity to green. In his conclusions the emphasis is on the position of this maximum rather than on the details of the threshold visibility curve. The first problem, his more immediate incentive, was the explanation of the striking simplicity of the spectra of the gaseous nebulae which in most cases consist merely of lines in the green and the blue-green, λ 500,495 and 480 $\mu\mu$. Two theories of this phenomenon had already been advanced: first, that only these wave-lengths are emitted, and second, that there is selective absorption in intra-nebular space. Ebert thought it more probable that the cause lies within the observer. That is, if the eye should prove to be most sensitive to green, it would be reasonable to expect that in a weak spectrum, such as that given by the gases, only the green would be visible. His second, more general motive, was the reopening for discussion of the whole psychophysical question, a subject made pertinent by the work of Weber (2) and Stenger (3) on Draper's law during the previous year. In discussing the results obtained in this work, Weber had assumed a direct proportionality between the responses of the eye and the energy of the light wave. Stenger had pointed out the incorrectness of this assumption but his discussion of the matter had been slight enough to warrant a more complete investigation by Ebert.

Draper's law refers to the order in which the wave-lengths of the visible spectrum emitted by incandescent solids reach the threshold of sensation with increase of temperature. Draper had stated that all metals begin to glow at the same temperature, about 525° C., and that the development of the light emission runs the following definite course: at 525° the light emitted gives

a spectrum which reaches from line B to line b; at 625° from B to F; at 718° from B to G; and at 1165° it gives a spectrum approximating that of the sun in extent. According to Draper, then, the spectrum of a glowing solid whose temperature is gradually increased develops practically in one direction only—from red to blue.

In the course of some experiments on the relation between the brightness and consumption of energy in carbon lamps, Weber had noted some entirely unexpected phenomena which caused him to doubt the correctness of this law. Watching the development of the light emission of the carbon filament with increase of temperature in a dark room, he noted that the red glow was not the first light visible, but that another light appeared and underwent an entire series of changes before there was any sign of color. This light he designated as "gespenstergraue" or "düsternebelgraue." At first it was very unstable, although whether its rapid appearances and disappearances were due to change of intensity of the light because of fluctuation in the temperature of the filament, or whether they are due to an eye phenomenon, he did not know. With a slight increase of intensity the light became a little less variable although it retained its "düstergraue" quality. With greater increase the gray lightened, and the coloration gradually changed through an ashgray to a definite "gelblichgraue." By the time the red glow was visible, the light had become fixed, losing the flickering quality which it had had throughout the previous changes.

A prismatic analysis of this first gray light with the complete spectroscope was not possible because of the weak intensity, but Weber was able to observe the changes through a direct vision prism, and, at slightly higher intensities, through a grating. The spectrum of the "düsternebelgraue" light, when first strong enough to be seen through the prism, consisted of a homogeneous gray strip which occupied the position where at higher intensities yellow and yellow-green appeared. As the temperature was increased this strip broadened and brightened. When the temperature had reached a degree such that with the naked eye the light looked "gelblichgraue," its spectrum was seen as a broad

band, yellowish-gray in the center and shading to a weak gray on either side. When, viewed by the naked eye, the light was reddish, there appeared in the spectrum at one side of the gray strip a small " feueroth " space, and almost simultaneously on the other side a gray-green strip. As the light became whiter with increase of temperature the spectrum continued to develop until finally the entire spectrum was present. This description of the light emission of a glowing solid was verified by Stenger, who repeated Weber's experiment.

It is in his conclusion that Weber makes the assumption that visibility is proportional to energy, an error which, as was stated above, was pointed out by Stenger. Weber states his conclusions as follows:

" Das Spectrum des glühenden Kohlenfadens wächst also bei steigender Temperatur nicht einseitig, in der Richtung vom Roth nach dem Violett, sondern entwickelt sich, von einem schmalen Streifen ausgehend, genau von seiner Mitte aus, gleichmässig nach beiden Seiten. Die dem Auge zuerst erscheinende, den Ausgangspunkt der Spectrumsentwickelung bildende Strahlung ist dieselbe Strahlung, die im vollständig entwickelten sichtbaren Spectrum dem Auge mit der grössten Helligkeit leuchtet und in dem schwarzen Flächen der Thermosäule und des Bolometers die maximale Energie entwickelt.

" Daraus ist wohl der Schluss zu ziehen, dass diese Strahlung mittlerer Wellenlänge deswegen dem Auge am frühesten sichtbar wird. weil sie auch schon bei der Temperatur der beginnenden Grauglüht die maximale Energie besitzt, infolge dessen ihre lebendige Kraft am frühesten jenen Schwellenwerth übersteigt, welcher vorhanden sein muss, um eine Lichtempfindung zu veranlassen, und dass die übrigen Strahlungen kleinerer und grösserer Wellenlänge dann bei steigender Temperatur der Reihe nach dem Auge sichtbar werden, sobald deren lebendige Kraft einen Schwellenwerth ähnlicher Grösse überstiegen hat."

Stenger, referring to Langley's (4) results on the energy distribution of the sun's spectrum, showed that since the greatest energy is in the red, not in the green or yellow-green, the eye must be *selectively* sensitive, and that the maximum of this sensitivity must lie in the green.

It was at this point that Ebert took up the problem. The details of his experiment are as follows: The source of light was a gas flame which illuminated from behind a screen of oiled paper. This screen was assumed to be evenly illuminated and was focussed on the slit of the spectroscope by a lens 12 cm. in

diameter placed at 125 cm. from the slit. The observer, looking through the objective slit, saw the face of the prism filled with spectral light. The intensity of the light was then reduced until it was no longer visible. For each wave-length used, determinations of the threshold were made in ascending and descending series, and the mean of the two series calculated. The variation amounted to between 2 and 3 per cent. His values are for only five different wave-lengths and for two observers. The length of the adaptation period is not given; Ebert states merely that the experiment was performed after " sufficient " dark-adaptation.

The reduction of the light intensity was obtained by a diaphragm, .07 cm. in diameter, placed between the focussing lens and the collimator slit, and so mounted that it could be moved over the entire distance—125 cm. As this diaphragm is moved nearer to the focussing lens, it decreases the diameter of the used portion of the lens, thus reducing the intensity of light focussed at the slit. If E is the distance of the diaphragm in cm. from the slit, and D the diameter of the used portion of the lens, then

$$D = \frac{125 \times .07}{E}$$

The intensity of any part of the spectrum is then proportional to D^2.

The distribution of energy in the spectrum of the light source used was calculated indirectly by combining the results of Langley mentioned above, with those of Meyer (5), who had checked the energy distribution of a gas flame, the source used by Ebert, against that of the sun. Langley, using a bolometer, had determined the energy distribution of the sun's spectrum in relative terms, *i.e.*, in terms of galvanometer readings—no absolute values are given. Meyer had compared photometrically the spectrum of a gas flame with that of the sun, obtaining a series of ratios representing the energy distribution of the gas flame relative to that of the sun. Ebert, to get the energy distribution of his own source, multiplied the values given by Langley by the appropriate

ratios as given by Meyer. The results of these calculations are shown in Table I, quoted from Ebert.

TABLE I

Farbe	Mittlere Wellenlänge	Helligkeit Gaslicht / Helligkeit Sonne (Meyer)	E Sonne (Langley)	E Gaslicht
Roth	675 $\mu\mu$	4,07	62	252
Gelb	590 $\mu\mu$	1,00	45	45
Grün	530 $\mu\mu$	0,43	28	12
Grünblau	500 $\mu\mu$	0,43	22	10
Blau	470 $\mu\mu$	0,23	14	3

In this table the second column gives the middle wave-length of the various spectrum bands used; the third volumn gives the ratio of brightness of gas flame divided by brightness of sun for the particular wave-length; the fourth column gives the relative energy of the same wave-lengths as determined by Langley; and the fifth, the product of the third and fourth, shows the *relative* energy distribution in the spectrum of a gas flame.

Such a calculation would, at best, yield results only approximately correct, and in this case it is still further open to criticism in that Ebert did not use exactly the same wave-lengths as Meyer. As was said previously, however, he lays little stress on the shape of the visibility curve, insisting only that the maximum lies in the green.

The final threshold values were obtained in relative terms by multiplying the values given in column 5 of the above table by D^2. Since sensitivity is taken as the reciprocal of the threshold value of the stimulus, the relative sensitivities of his observers were as the reciprocals of these products. The values of these reciprocals are given in Table II.

TABLE II

Observer	Red	Yellow	Green	Blue-Green	Blue
S.	1/25	1/15	1	1/1.3	1/3
E.	1/34	1/17	1	1/2	1/4

In 1889 Langley (6) himself published results bearing on the visibility of radiation. He wished "to make the novel calculation as to the actual amount of energy either in horse-power or any other unit, required to make us *see*."

Unlike Ebert, Langley determined the minimum visible by means of reflected light. A piece of white paper on a black screen was illuminated by spectral light of different wave-lengths. As source he used the sun—reflecting its rays into the spectroscope by means of a siderostat mirror. The gross reduction of intensity was accomplished by reducing the effective area of the collimating lens by placing before it a metal plate pierced by a minute aperture, by a sectored disc, and by a glass screen very lightly smoked. The finer reductions were made by varying the width of the collimator slit. By actinometric measurements, Langley found the solar radiation to be 1.5 calories per square centimeter per minute. Knowing the reductions made, and estimating the absorption through the optical system, he calculated the values of the minimum visible for four wave-lengths to be as shown in Table III.

TABLE III

Color	Wave-length	Energy (ergs)	Ratio of Energies
Crimson	750 $\mu\mu$	1/780	450000
Scarlet	650 $\mu\mu$	1/1600000	230
Green	550 $\mu\mu$	1/360000000	1
Violet	400 $\mu\mu$	1/1500000	240

These results are for one observer only. The fourth column shows the relative energy values of the threshold for the four wave-lengths in question. Langley says of these results that they are subject to variations of a wide range, and may perhaps be in error by as much as 100 per cent.

The next results bearing on the subject are those of König (7), who, as part of an extended experiment on the relative brightness of different bands in the spectrum at various intensities, determined a threshold visibility curve. He used the Helmholtz spectrum color mixer, reducing the intensity of the light by means of slit width. Like Ebert, he used Langley's figures representing the relative energy distribution in the sun's spectrum, multiplying them by ratios previously determined by himself and Dieterici in a comparison of the energy distribution of the spectrum of a triplex gas burner (the source used) with that of the sun. His data are for two observers and fourteen wave-lengths. Table IV

shows the relative sensitivity of the two observers to the wave-lengths employed. The method of calculation is similar to that of Ebert, described above.

TABLE IV

Wave-length	Observer A.K.	R.R.	Av.	Wave-length	Observer A.K.	R.R.	Av.
670 μμ	.00019	.00017	.00018	535 μμ	.75	.60	.68
650 μμ	.00047	.00056	.00051	520 μμ	.98	.83	.90
625 μμ	.0038	.0048	.0043	505 μμ	1.00	1.00	1.00
605 μμ	.015	.019	.017	490 μμ	.86	.75	.80
590 μμ	.045	.033	.039	470 μμ	.50	.50	.50
575 μμ	.12	.12	.12	450 μμ	.23	.26	.25
555 μμ	.36	.33	.35	430 μμ	.047	.059	.053

Pflüger (8), in taking up the problem in 1902, adopted a procedure similar in principle to that of Ebert. Unlike Ebert, however, he determined the energy distribution of the source directly with a thermopile, although only in relative terms. Also a greater number of observers was used.

A Nernst filament was used as source, the light from which was focussed on the slit of the spectrometer by a condensing system composed of two triple achomatic lenses. This seemed to satisfy best the need for a source whose intensity was both constant and sufficiently great to permit of direct measurement in the violet. The energy measurements were made by means of a Rubens thermopile mounted at the objective of the spectroscope, and a DuBois-Rubens galvanometer. The radiometric apparatus was not, however, calibrated against a standard, and the energy curve is, therefore, in terms of galvanometer readings, not absolute units.

In order to allow for the reduction of the light to the threshold of sensation, slight changes in the arrangement of the apparatus had to be made. The ocular slit was shortened to ¾ mm. in height, which with the breadth of ½ mm. was considerably smaller than the observing pupil. Milk glass was placed over the collimating slit to give evenness of field brightness, and the focussing lenses removed. The energy measurements were corrected for the absorption of the milk glass and an attempt was made to compensate for the absorption of the lenses by inserting glass plates in the beam of light. A bar four meters long was

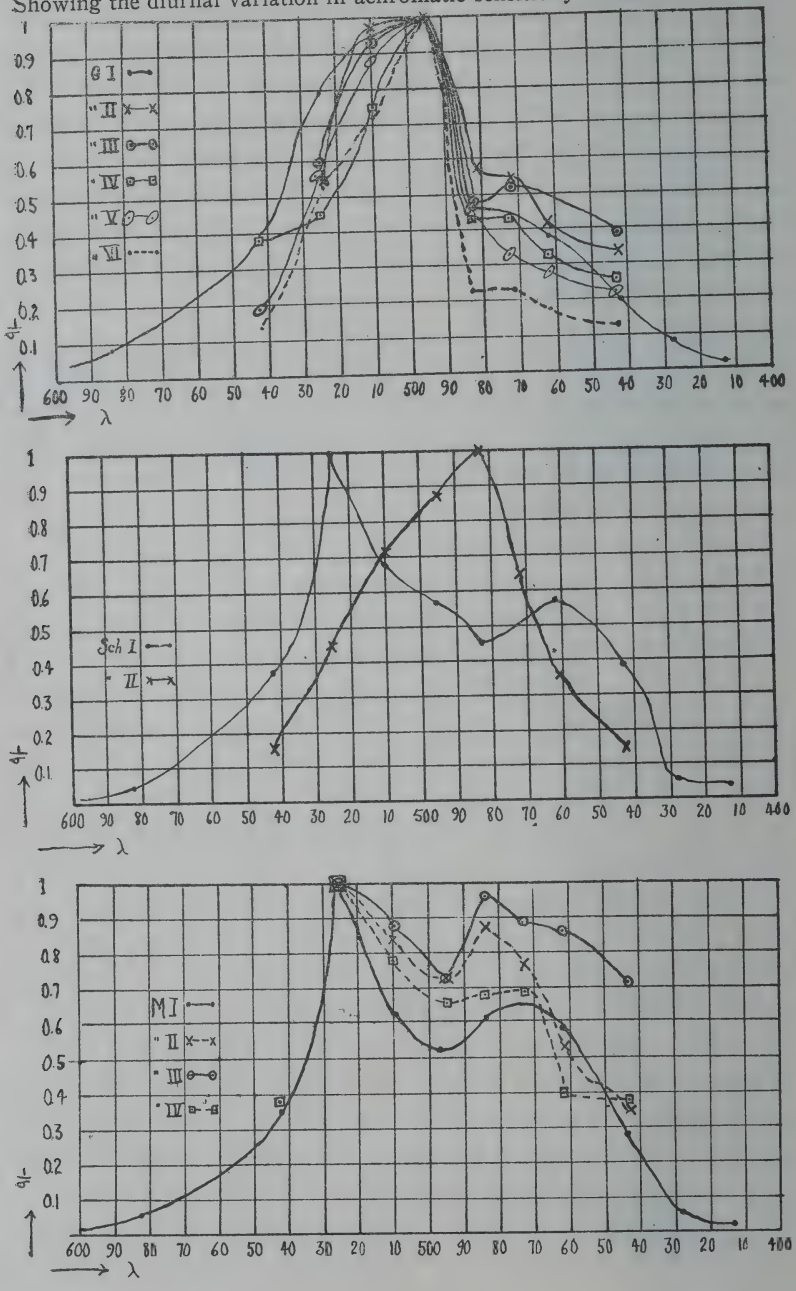
added to the collimator arm. The illumination of the milk glass could then be varied by changing the position of the Nernst filament on this bar. A further reduction was made by introducing a sectored disc into the path of the ray, and the final reduction was obtained by varying the slit width. The observer, looking through the objective slit, saw the face of the prism illuminated with spectral light. To aid in maintaining fixation a milled ring was placed at the ocular slit. The diameter of the lighted surface subtended an angle of about 12 degrees, its image being, therefore, much larger than the fovea, larger even than the macula.

The procedure was very tedious, says Pflüger. Three readings were taken for each determination; then the whole series was repeated in reverse order. With few exceptions the second series was found to correspond to the first within the experimental error of the first. When this was not the case the whole series was repeated. Errors for single measurements were high, sometimes reaching 10 per cent. The average error was 4 per cent. Results are given for nine observers, and the curves for different days are plotted separately. The original intention was to average all the results for a given observer, but so much diurnal variation was found to exist that the plan had to be abandoned. The question of this large variation from day to day being found simultaneously with a comparatively small variation for any one sitting will be discussed later. In a few cases nineteen points in the spectrum were employed as stimuli, but the bulk of the curves are plotted for eight points. To get the final values the slit width readings were averaged, then reduced to what they would have been with the source at a distance of one meter and with 360° open sector. The reciprocal of this value is taken as the measure of the sensitivity. The greatest sensitivity in any series is taken as unity, and the other values are made proportional. The position of this maximum sensitivity varies widely, not only from individual to individual, but from day to day in the results of the same individual. Three curves selected as typical are reproduced in Figures I, II, and III. Figure I gives the curves for an observer who shows comparatively little diurnal variation. For six days the maximum sensitivity was at 495 $\mu\mu$. There is con-

siderable variation, however, at other wave-lengths. Figure II gives curves for an observer whose diurnal variation is extreme. For example, on two days the maximum sensitivity occurred respectively at 525 $\mu\mu$ and 485 $\mu\mu$. Figure III gives the curves of an observer in which the tendency toward a secondary maximum is pronounced. Varying degrees of this tendency are shown in many other curves in Pflüger's series. From such data it is evident that Pflüger could draw no conclusions as to the exact shape of the threshold visibility curve—he could merely give the general characteristics of such a curve. His conclusion is:

"Die absolute und die relative Farbenempfindlichkeit des Auges, gemessen bei den Schwellenwerten der Reizempfindung, ist grossen individuellen Verschiedenheiten, und, bei demselben Auge, grossem Wechsel unterworfen. Die Empfindlichkeit ist am grössten für den Spectralbereich $\lambda = 495\ \mu\mu$ bis $\lambda = 525\ \mu\mu$. Sie kann für $\lambda = 717\ \mu\mu$, den 33000ten, für $\lambda = 413\ \mu\mu$ den 60ten Teil des Wertes im Grün betragen."

FIGURES I–III. Sensitivity Curves (Pflüger).
Showing the diurnal variation in achromatic sensitivity of three observers.



III

APPARATUS AND PROCEDURE

In any quantitative determination of the amount of light needed to arouse a just noticeable sensation for any given group of wave-lengths there are two essential requirements: (1) We must have a means of presenting to the eye the desired range of wave-lengths free as nearly as possible from alien wave-lengths; and (2) we must have some means of measuring the energy of the stimulus thus presented and of reducing its intensity by known amounts. The greater part of the spectroscopic and radiometric apparatus needed to fulfil these two requirements was already in use in the Bryn Mawr laboratory when the present work was undertaken.[2] The description of the apparatus as modified to meet the needs of the present investigation, together with the necessary additions, is given under five headings: the source of light; the spectroscope; the apparatus for presenting the light to the eye; the devices for reducing the intensity of light; and the radiometric apparatus. The procedure is described under two headings: the energy measurements; and the methods of observation. A drawing showing the path of the beam of light and the arrangement of the apparatus is given in Figure IV; a photograph of the assembled apparatus in Figure V.

A. The Source of Light. The source of light was a Nernst filament operated at 0.6 ampere. This source was chosen because when properly seasoned it gives a light very constant in both intensity and radiometric composition, and at the same time sufficiently intense to permit of direct energy measurement. Its shape also well adapts it for use with the slit of the spectroscope, *i.e.*, the shape is such as to make it possible to utilize for the illumination of the face of the prism a relatively large part of the light emitted. When in use the filament is placed directly in front of the slit and as close to it as is possible. This placement

[2] For description of this apparatus see References (9) and (10).

of the filament, however, presents two difficulties. In the first place the Nernst material must be heated before it will conduct the electric current. This requires that the filament be moved from its position in front of the slit prior to each period of work. In the second place the terminal wires, which are of platinum and very pliable, give little stability of position to the filament. Because of these difficulties a special mounting had to be devised which would provide for the adjustments required for the removal and precise resetting of the filament and would give the rigidity of support needed to prevent sagging or other displacement of the filament from its position in front of the slit. On this latter point it may be noted that if care is not taken that the light which enters the slit come always from the same part of the filament, variations both in its composition and intensity may occur. This mounting is shown in Figure IV.

B and C are two metal arms at the ends of which are attached the terminal wires of the filament N. B and C are supported by a piece of asbestos A, which is in turn fastened to the rod D by a pin E. E serves a double purpose: by its use B and C are supported in a manner which not only provides for both heat and electric insulation, but which also allows a slight rotary movement necessary for perfect alignment of the filament with the slit. The height of D is adjustable and F is fastened by a collar to a round rod attached to the collimator arm, thus permitting movements of the mounting back and forth, right and left, and up and down. Around the whole is a metal housing ventilated at top and sides, but in such a manner as to remain light-proof. The filament is connected in series with a Weston ammeter graduated to 0.02 ampere; a ballast which both reduces the current and compensates for the change in the resistance of the Nernst with change in temperature; and two adjustable rheostats, one coarse, the other fine. The former is used to cut down the current to approximately the desired value and the latter to correct for the fluctuations in the line.

B. The Spectroscope. A diagramatic representation of the spectroscope is shown in the drawing given in Figure IV. S_1 is the collimator slit; L_1, the collimator lens; P, the prism; L_2, the

objective lens; S_2, the objective slit. L_3 to L_4 is the system for focussing the light on the eye. The collimator slit S_1 is 12 mm. high, and its width can be varied by means of a micrometer screw fitted with a head graduated to read to thousandths of an inch. This slit was set at a width sufficient to allow of the radiometric measurements being made with precision, and was kept constant throughout the experiment. Lenses L_1 and L_2 are both Zeiss triple achromats, 60 mm. in diameter; the collimator has a focal length of 180 mm., the objective of 240 mm. A carbon bisulphide prism 105 mm. high, with a refracting angle of 60 degrees, was used. With the exercise of a reasonable amount of precaution to keep the CS_2 free from impurities and to maintain a uniform temperature in the room, this prism has given satisfaction. If the temperature is not kept constant the change of refractive index of the CS_2, resulting from the change in temperature, necessitates frequent checking and resetting of wave-length. The objective slit is 0.342 mm. wide and adjustable in height. For the radiometric measurements a height of 10.4 mm. was used; for the work with the eye this was reduced to 1.85 mm. The greater length was necessary in order to obtain an intensity sufficiently high to make the energy measurement; for the eye work, however, a much smaller slit is needed in order that the image which is focussed on the eye may fall entirely within the pupil. This slit is mounted on an independent base screwed to the table in a fixed relation to the base of the spectroscope. In order that the distance of the slit from the lens L_2 may be adjusted for the different focal distances of different wave-lengths, the frame on which the slit is mounted is furnished with a rack and pinion R. Lens L_3, which serves as collimator in the system for focussing the light on the eye, is mounted on the same rack and pinion so that the distance between S_2 and L_3 (the focal length of L_3) remains always constant.

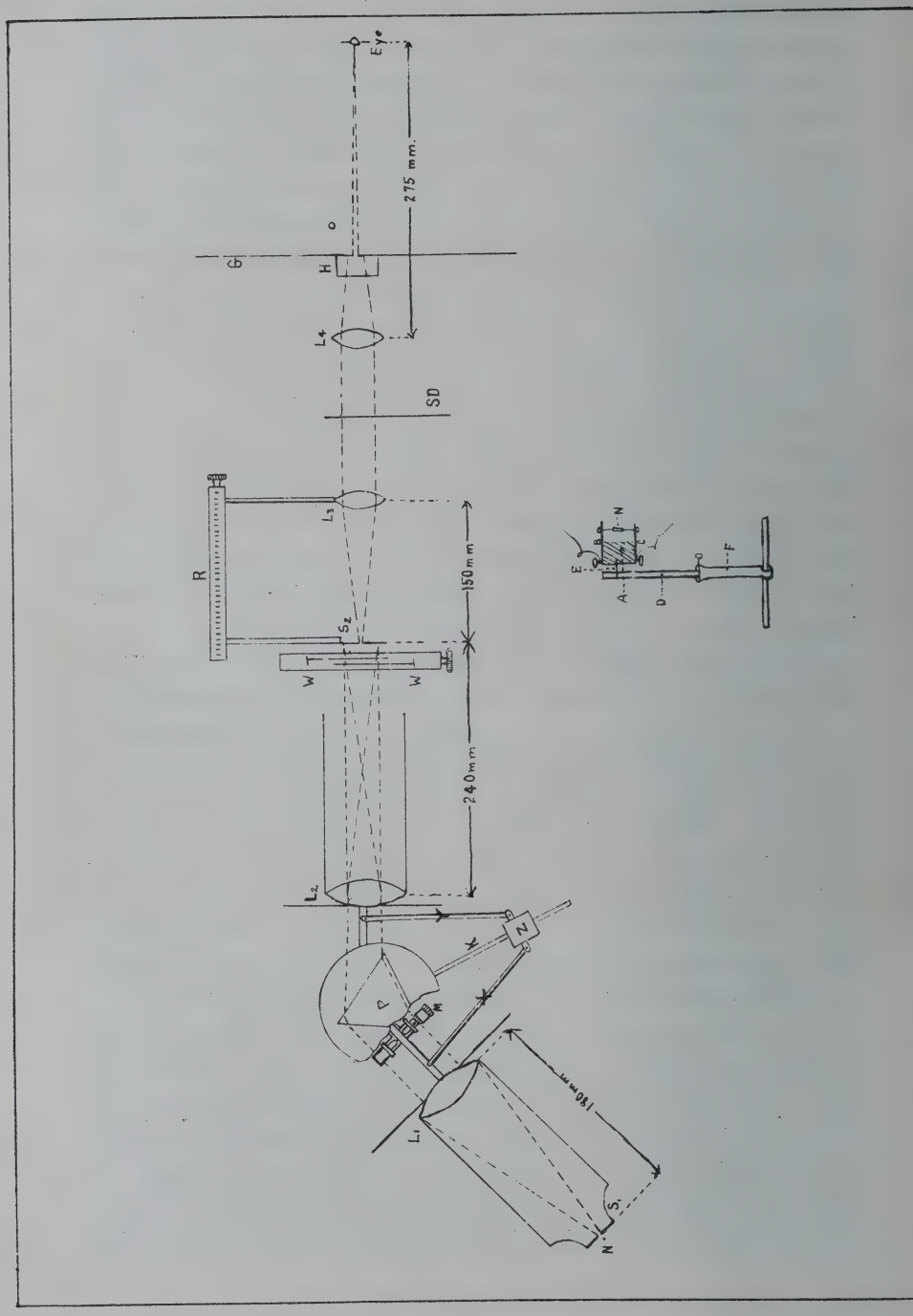
In order to obtain automatically minimum deviation for all wave-lengths falling on the objective slit, the spectroscope was fitted with a special attachment for the purpose. K in Figure IV is a rod fastened to the prism table in such a position as to be continuous with the radius of the table which bisects the refracting

angle of the prism; X and Y are two rods of equal length fastened at one end to the two arms of the spectroscope at points equidistant from the center of the prism table, and at the other to a collar Z, which is free to play back and forth along rod K. M is a micrometer screw with a graduated head which is used to move the collimator arm through the small angles needed to change the wave-length. Opposite this screw is a plunger working against a spring. The collimator arm is held between the screw and the plunger so that it responds to a movement of the screw in either direction. By this attachment the prism is always turned through half the angle traversed by the collimator arm in changing the wave-length. Therefore if the prism is once set for minimum deviation for the D-line, there will also be minimum deviation for any other wave-length. That is, when the prism is set for minimum deviation, the line bisecting the refracting angle of the prism also bisects the angle made by the incident and emergent rays, hence if in changing the wave-length the angle between the incident and emergent rays be changed a given amount by a movement of the collimator arm, the prism must be moved through half that angle in order that the line which bisects its refracting angle will also bisect the angle made by the incident and emergent rays.

In all quantitative work on color sensitivity it is very important that the light employed be as homogeneous as possible as to wave-length. The presence of alien visible wave-lengths affects the determination of chromatic sensitivity in two ways: (1) It decreases the amount of the color response through physiological inhibitions and interactions, and (2) it increases the value of the energy measurements. In the work in this laboratory determinations made with and without provision for absorbing impurities due to scattered light, internal reflections, etc., show differences large enough to be considered significant. In the present investigation the aim has been to obtain a degree of purity such that any portion of the spectrum used should show only one band when examined with a second spectroscope. In order to secure purity of light the following precautions were taken. The spectroscope was provided with the minimum deviation attachment already

noted. Great care was employed in eliminating as far as possible all stray light and internal reflections. The source was housed as described above and a screen was placed at the objective lens to prevent any stray light from the prism from reaching the farther parts of the system. As far as could be all surfaces that might either admit or reflect extraneous light into the path of the refracted beam were blackened, and as a final precaution a light-tight housing was built around the whole apparatus from just in front of the collimator slit to just beyond the lens which focussed the light on the eye. This compartment was large enough to permit of the experimenter working inside. Even with these precautions, however, some impurities remained, chiefly those due to reflections from the surfaces of the lenses. These were absorbed out by very thin gelatine filters, carefully selected with reference to the bands to be eliminated. The gelatine filters were held in place over the objective slit by small clips fastened on either side of the plate containing the slit. The filters were used both for the radiometric measurements and for the threshold determinations.

C. Apparatus for Presenting the Light to the Eye. There are several methods by which we may obtain a homogeneously illuminated surface suitable for determining thresholds of sensation: (1) Spectrum light of the desired range of wave-lengths may be allowed to fall on some diffusively reflecting surface, such as magnesium oxide, which in turn is viewed by the eye; (2) spectrum light may be allowed to fall on some diffusely transmitting surface; or (3) spectrum light may be focussed directly on the pupil of the eye by means of a double convex lens. The third of these possibilities was chosen for this work. The use of either of the first two methods necessitates the assumption that the reflecting or transmitting surface is absolutely nonselective to wave-length. Both methods, moreover, are very wasteful of light—not only is there a comparatively high percentage of absorption, but also only a small percentage of the light coming from any point of the stimulus surface enters the pupil of the eye. Under these conditions it would be very difficult to specify accurately in radiometric units either the unit density or the total


Eye
275 mm.
G
H
O
L4
SD
L3
R
S2
150 mm
W
W
240 mm
L2
N
L1
180 mm
S1
N
E
B
N
S
A
D
F

amount of the light at the eye. That is, the energy value at the eye could not be measured; it could be calculated only approximately. An accurate energy specification is possible, however, when the light is focussed on the eye. The light, by this method, does not spread from the stimulus opening as if emanating from a source, but is concentrated into an image on the pupil of the

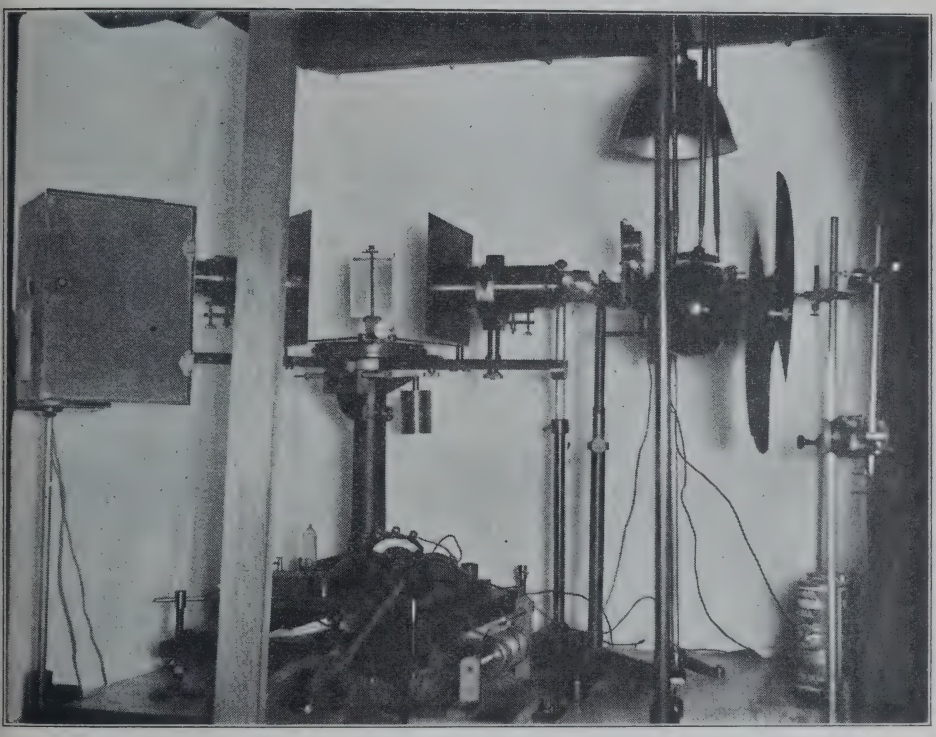


FIGURE V

eye—an image of the objective slit of the spectroscope. The amount of energy concentrated into this image can readily be determined with the radiometric apparatus to be described later.

In order to present the stimulus in compliance with the above plan, the rays of light emerging from the objective slit are first rendered parallel by lens L_3 (Fig. IV) placed at its focal length (150 mm.) from the objective slit, and are then focussed on the

eye by lens L_4, focal length 275 mm. In this way ample space is obtained for the introduction into the system of any apparatus necessary for reducing the intensity of the beam of light, *i.e.*, sectored disc, filters, etc. The dimensions of the image at the eye were determined by photographing it on a plate carefully mounted in the plane of the pupil and measuring the photographed image with a micrometer comparator. These dimensions were 3.7326 mm. $\times$ 0.6956 mm. Since this is well within the pupil of a dark-adapted eye, the use of an artificial pupil with its attendant difficulties is avoided.

In front of L_4, 240 mm. from the eye, a screen G is placed containing a circular opening O, 10 mm. in diameter, which serves to diaphragm the lens L_4 to the desired stimulus aperture. When the eye is in position the exposed area of the lens L_4 is seen filled with light. The visual angle subtended by this area is 2° 2.2′.

D. Means of Reducing the Intensity of Light. Because of the small amount of energy required to arouse a just noticeable sensation of light, it would be impossible to measure this energy directly with a thermopile. It is necessary, therefore, to measure the energy at a high intensity and to reduce this intensity by known amounts to the intensity required. In order to obtain the range of reduction necessary for all observers, three methods of cut-down were utilized.

1. *The Filters.* The main reduction of light was made by the insertion in the light beam of neutral filters, combinations of which allowed for a possible range of transmission of from 1148×10^{-5} to 141×10^{-12}. The filters are of gray gelatine mounted between glass, 25 mm. by 25 mm. They were made by the Eastman Kodak Company. The densities were specified by the Eastman Kodak Company and the transmission of each filter was calculated by the formula:

$$\text{Density} = \log \frac{1}{\text{Transmission}}$$

A holder designed to take any combination of filters up to eight was placed at H in contact with the screen G. This position

of the filters precluded the possibility of any scattered light not completely absorbed being transmitted through the screen opening to the eye of the observer.

2. *The Sectored Discs.* Any further large reduction needed was obtained by the use of a pair of sectored discs inserted at SD. These discs were rotated by a small motor suspended from above by coiled springs to absorb vibration. The range of open sector used was from 180° to 0°.

3. *The Wedges.* The final reduction was made by means of the two wedges WW mounted immediately in front of the objective slit. Early in the work it was realized that for any accurate threshold determinations a means must be had of making very small changes in the intensity of the stimulus, and that the method employed must insure a perfectly uniform reduction throughout the cross section of the beam of light. A single wedge such as is ordinarily employed does not give this required uniformity of reduction. When placed in front of the slit, no matter how fine the gradation in density, there is always a slight difference in transmission between the opposite edges of the used portion of a single wedge. A double wedge device was therefore planned to obviate this difficulty. The two wedges were made according to specification and calibrated by the Eastman Kodak Company. Like the filters, they are of neutral gelatine mounted between glass. The wedges are identical, each being 135 mm. by 13.5 mm., and so constructed as to cover the same range of transmission. They are mounted parallel to each other in holders which are operated by a micrometer screw. These holders are provided with right- and left-handed threads. As the screw is turned the wedges move in opposite directions, each wedge traveling in front of the other through a path equal, if need be, to twice the length of one wedge, that is, from a position of juxtaposition at the thin end of each wedge to a position of juxtaposition at the thick end. Since the density gradients of the two wedges are identical and the wedges move in opposite directions, it is obvious that the resultant densities will be the same from point to point throughout the overlapping section. A consideration of the range of movement shows further that a series of densities may be obtained

varying by minute amounts from the sum of the minimum densities of both wedges, through the sum of the minimum of one and the maximum of the other to the sum of the maxima of both.

The density in this case also equals the log of $\frac{1}{\text{Transmission}}$.

E. The Radiometric Apparatus. The apparatus used consisted of a linear thermopile of silver and bismuth couples, a Paschen small coil galvanometer especially constructed for the thermopile employed, and suitable auxiliary apparatus. These instruments were constructed by W. W. Coblentz of the Radiometric Division of the Bureau of Standards. The apparatus has been described in an article by Dr. Ferree and Dr. Rand (10), and the reader is referred to this article for further details. All the radiometric measurements were made by Dr. Rand, to whom I am deeply indebted for the values given below. The procedure of making these measurements is quoted from the article just mentioned.

F. The Energy Measurements. The apparatus for measuring the energy is so planned that measurements may be made at the objective slit, at the stimulus opening, and at the eye. A description at one of these places, namely, the objective slit, is sufficient to show in a general way the method employed.

"The thermopile to be used was placed in position immediately behind the slit and a blackened aluminum shutter was interposed in the path of the beam of light between the slit and the end of the objective tube of the spectroscope. Preliminary to the exposure of the thermopile to the light to be measured, the current sensitivity of the galvanometer was tested by means of a special device provided for this purpose in the construction of the galvanometer. With regard to this procedure it may be pointed out that the current sensitivity of the galvanometer varies with the period or time of the single swing of its needle system. Since it is not possible to control the field so as to get this period always the same, it is necessary, if results are to be compared, to take some sensitivity as standard and to convert all readings into deflections

for the standard sensitivity by means of a correction factor determined at each sitting. (For a detailed description of the method of determining this factor, see PSYCHOL. REV. MONOG., 1917, **24**, No. 2, pp. 60–65.)

"The thermopile was next connected with the galvanometer and the light allowed to fall on its receiving surface until a temperature equilibrium was reached (ca. 3 sec. for our thermopile). The deflections were read by means of the telescope and scale and the readings are corrected to standard sensitivity by means of the factor previously determined. The final step in the process of measuring was the calibration of the apparatus, *i.e.*, the value of 1 mm. of deflection in radiometric units was determined for the area of thermopile exposed. To do this a radiation standard, the value of the radiations from which is already known, had to be employed. The standard used by us was a carbon lamp specially seasoned and prepared for the purpose by W. W. Coblentz. This lamp was placed on a photometer bar 2 meters from the thermopile and operated at one of the intensities for which the calibration was made, in our case 0.40 ampere. The thermopile was exposed to its radiations with the same area of receiving surface as was used in case of the lights measured, and the galvanometer deflection was recorded. From the deflections obtained the value of 1 mm. of deflection, or the radiation sensitivity of the apparatus under the conditions given, was computed from the known amount falling on the surface of the thermopile. Having the factor expressing the radiation sensitivity of the apparatus, the deflections produced by the wave-lengths of light measured were readily converted into energy units."

The radiation sensitivity of the linear thermopile as used in the present investigation was computed from the following data. The energy value of the radiations per square millimeter of receiving surface from the standard lamp at a distance of 2 m. operated at 0.40 ampere was 90.70×10^{-8} watt. The deflections of the galvanometer produced by this intensity of radiation falling on the same area of receiving surface as was used in measuring the lights employed as stimuli, when corrected (a) to a sensitivity

of $i = 1 \times 10^{-10}$ ampere, and (b) for the absorption of the glass cover of the thermopile, was 323.85 mm. The area of the surface exposed was 3.5657 sq. mm. The value of 1 mm. of galvanometer deflection, or the sensitivity of the instrument for the area of receiving surface used, was, therefore, 998×10^{-11} watt. By means of this factor the galvanometer readings produced by the different wave-lengths of light were readily converted into the energy value of light falling on the receiving surface of the thermopile. For the purpose of the present investigation, however, it is needed to know also the energy values of the light entering the eye. These are sufficiently great only in the case of red and orange to be measured directly with the required precision. It was necessary, therefore, to measure all the wave-lengths used at the objective slit and only the red or orange at the eye, and from the comparative values of the red or orange at the two places to determine a correction factor which will represent for all the colors the reduction of the light from objective slit to eye. In order to determine this reduction factor with precision a larger area of receiving surface of the thermopile had to be exposed to the light than the actual area of the image entering the eye for the threshold determinations. It will be remembered that the height of the objective slit and consequently the height of the image focussed on the pupil of the eye was adjustable. In the present work the receiving surface of the pile used to measure the light at the eye was $11.2548 \times .895$ mm., or 10.073 sq. mm. The value of 1 mm. deflection of the galvanometer for this area of receiving surface was 88×10^{-10} watt. Since the focussed image is of uniform density, the energy for the area of the image at the eye, $3.7326 \text{ mm.} \times .6956$ mm., or 2.5967 sq. mm., could be readily determined. From these values a single factor was calculated which would convert the amount of energy for the different wave-lengths measured at the objective slit into the amounts of energy entering the eye. These values are given in Table V. A division of these values by 2.5967 will give the energy density at the eye, a division by 78.54 the energy density at the stimulus opening.

TABLE V

Red	655 $\mu\mu$ = 300	$\times 10^{-9}$
Orange	616 $\mu\mu$ = 133	"
Yellow	580 $\mu\mu$ = 16.2	"
Yellow-green	553 $\mu\mu$ = 24.8	"
Green	522 $\mu\mu$ = 14.8	"
Blue-green	489 $\mu\mu$ = 9.86	"
Blue	463 $\mu\mu$ = 9.19	"

G. The Methods of Observation. The experiments were conducted in a light-tight dark-room, the walls, floor, and ceiling of which were painted black. In the preliminary work it was found that an adaptation period of twenty minutes was sufficient to give constant results in the determination of chromatic thresholds. For the achromatic thresholds a much longer adaptation period was needed. The observer was seated in front of the apparatus, the eye being at the focal length of the lens L_4. To ensure steadiness of position the head was held rigid by means of a wax-coated mouthpiece in which the impression of the teeth had previously been made and hardened. The other eye was lightly bandaged with a black cloth. The determinations were made in ascending and descending series. The edges of the stimulus opening were touched at suitably spaced intervals with luminous paint to enable the observer to take and hold the correct fixation. A rough adjustment of the filters and sectored disc was made until an approximate value of the threshold was obtained, and then a rest period of several minutes was given and the exact value of the threshold accurately determined. In order to prevent a progressive loss of sensitivity from fatigue short rest periods were given after each observation. A number of independent determinations were made of the threshold value for each wave-length.

A similar procedure was employed for the determination of the achromatic threshold for each wave-length. In this case, however, even greater care had to be exercised to guard against progressive loss of sensitivity.

IV

STATEMENT AND DISCUSSION OF RESULTS

A. Achromatic Thresholds. The achromatic thresholds of the seven wave-lengths were determined for twenty-one observers. A complete statement of the results is given in Table VI, Parts A and B. A graphic analysis of Table VI is given in Figures VI–XIV.

The minimum visible for the different wave-lengths used was found to be as follows:

1. Red (655 $\mu\mu$)	Average = 626.99		watt $\times$ 10^{-16}
	Median = 637.67		"
	Range = 1209.27	— 186.48	"
2. Orange (616 $\mu\mu$)	Average = 130.28		"
	Median = 118.08		"
	Range = 273.77	— 70.72	"
3. Yellow (580 $\mu\mu$)	Average = 27.96		"
	Median = 25.74		"
	Range = 49.04	— 11.56	"
4. Yellow-Green (553$\mu\mu$)	Average = 2.203		"
	Median = 2.298		"
	Range = 3.242	— .718	"
5. Green (522 $\mu\mu$)	Average = 1.953		"
	Median = 1.868		"
	Range = 3.469	— 1.295	"
6. Blue-Green (489 $\mu\mu$)	Average = 8.11		"
	Median = 8.00		"
	Range = 13.8	— 2.96	"
7. Blue (463 $\mu\mu$)	Average = 15.62		"
	Median = 15.00		"
	Range = 29.53	— 6.28	"

The total range of minimum visible of the wave-lengths used is therefore from 1209.27, in the red, to .718 (watt $\times$ 10^{-16}) in the yellow-green, a ratio from highest to lowest of 1684.

The average sensitivity of the twenty-one observers was greatest in the green. The average threshold for this wave-length is 1.953 (watt $\times$ 10^{-16}). There is not, however, complete uniformity as to the position of maximum sensitivity. Nine observers show a maximum sensitivity in the yellow-green. Part A of Table VI gives the results of those whose maximum sensitivity

TABLE VI

ACHROMATIC THRESHOLDS

Amount of light entering the eye (watt $\times 10^{-16}$)

No. Observer	Red	Orange	Yellow	Yellow-Green	Green	Blue-Green	Blue
			A				
1. M.M.M.	922.41	103.53	45.74	2.208	1.405	9.58	15.23
2. L.M.	787.50	192.70	11.56	3.145	1.981	10.97	25.95
3. Md.B.	753.63	70.72	44.61	2.596	1.471	11.25	16.37
4. M.B.	689.28	91.14	32.13	2.107	1.295	3.83	8.16
5. E.C.	667.50	129.52	35.06	3.242	2.446	7.16	19.55
6. V.L.	648.83	217.17	35.53	3.220	1.868	8.00	11.06
7. L.L.S.	637.67	273.77	25.74	2.665	1.722	7.74	16.00
8. J.G.L.	626.22	106.24	31.08	2.586	2.116	8.46	14.14
9. M.O.L.	613.90	136.22	21.94	3.024	1.939	7.65	23.32
10. E.C.L.	609.84	123.17	49.04	2.512	2.268	10.50	18.31
11. T.W.L.	498.96	141.90	23.08	1.661	1.513	6.04	20.56
12. Md.B.L.	461.16	115.64	28.73	2.298	2.059	9.91	8.90
Mean—A	659.74	141.76	32.02	2.605	1.840	8.42	16.46
Median—A	643.25	126.35	31.61	2.591	1.904	8.23	16.18
			B				
13. J.G.	1209.27	118.08	25.56	2.480	3.450	8.26	15.06
14. T.W.	787.20	176.08	21.83	1.293	1.353	11.17	13.18
15. M.MC.	642.33	108.10	32.06	2.264	2.539	5.07	11.04
16. E.B.	641.28	88.20	20.74	.818	1.548	6.36	12.20
17. M.G.R.	597.00	119.36	21.14	2.203	3.060	13.80	23.19
18. M.O.	593.45	98.42	29.52	2.550	3.469	10.66	29.53
19. R.N.	305.71	135.42	14.38	1.622	1.718	7.79	13.00
20. E.B.L.	287.30	79.72	18.18	.718	1.395	2.95	7.07
21. H.K.	186.48	111.55	19.66	1.066	1.416	3.10	6.28
Mean—B	583.34	114.99	22.56	1.668	2.216	7.68	14.51
Median—B	597.00	111.55	21.14	1.622	1.713	7.79	13.00
Mean—A and B	626.99	130.28	27.96	2.203	1.953	8.11	15.62
Med.—A and B	637.67	118.08	25.74	2.298	1.868	8.00	15.00

lies in the green, Part B the results of those whose maximum sensitivity lies in the yellow-green. With two such distinct types a single measure of the general tendency of the group is misleading—the mean and median of the two groups were therefore calculated separately. As shown by these measures, the two types are quite different not only with regard to the position of maximum sensitivity but also with regard to the absolute value of the thresholds. With the exception of the green, the average threshold values of the yellow-green type are smaller than those of the green type. There is, however, on the whole, a wider range of values in the yellow-green type than in the green type.

In order to show more clearly the difference between these two groups, as well as to show the relative average sensitivity throughout the spectrum, the results of Table VI, A and B, were plotted

in the form of sensitivity curves. The reciprocal of the energy value was taken as a measure of the sensitivity. The maximum sensitivity for each observer was then made equal to unity and the other six values for the observer calculated as ratios of that value. Figure VI is the composite of the twenty-one sensitivity curves. In this composite we can distinguish not only the two groups

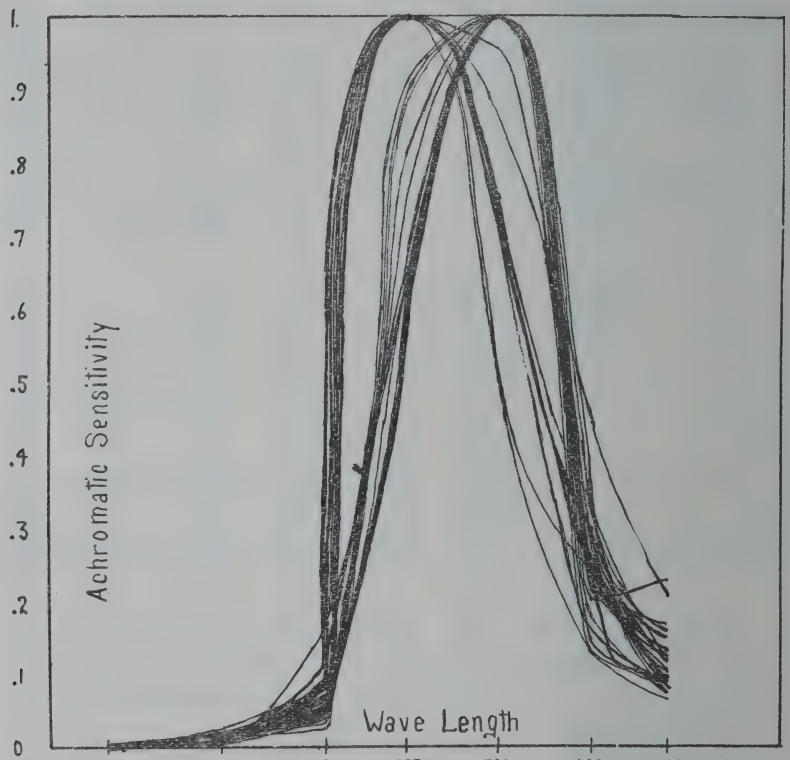


FIGURE VI

under discussion, but a possible third group. Two observers, although belonging to the type having maximum sensitivity in the yellow-green, are also very sensitive to green, as is indicated by the great breadth of the curve between wave-lengths 522 $\mu\mu$ and 553 $\mu\mu$. Similarly a few observers belonging to the type having maximum sensitivity in the green are very sensitive in the yellow-green. It is possible that the true maximum in both these

cases may be neither green nor yellow-green, but some intermediate wave-length. If the investigation in hand had been for the purpose of determining the exact shape of the threshold visibility curve for all types of observers, the region between 522 $\mu\mu$ and 553 $\mu\mu$ would have been carefully explored for all cases differing from the average in this way. The purpose of the study was, as has been stated, the determination of the minimum visible at

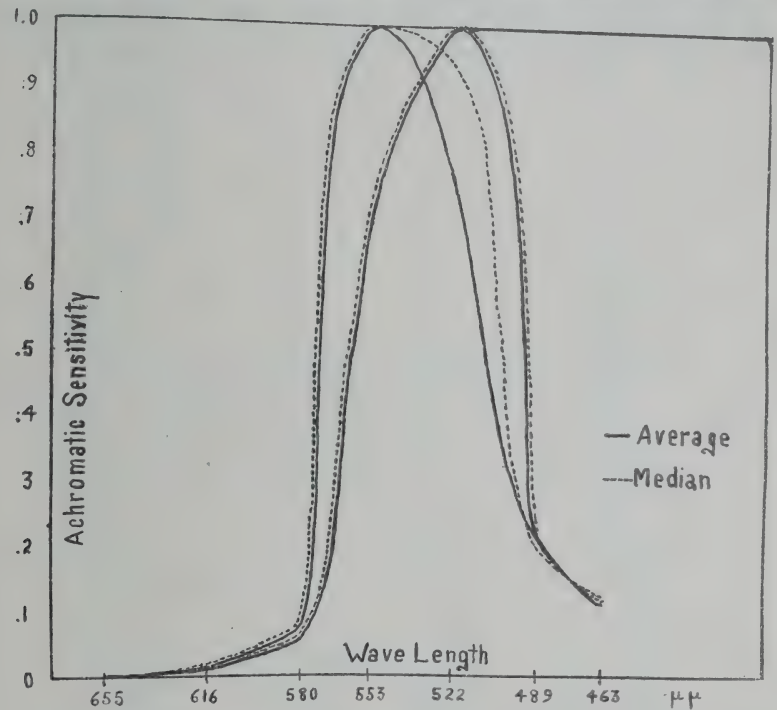


FIGURE VII

certain representative points throughout the spectrum. The possibility of a third type is offered, therefore, merely as a suggestion as yet unproved.

The mean and median values of the two groups were also calculated in the form of ratios of sensitivity. Figure VII gives these average sensitivity curves. The curves for the median and mean values agree very closely for the green type, and also for the yellow-green type except in wave-length 522 $\mu\mu$.

For all the wave-lengths employed the distribution of values around the average is approximately symmetrical. The frequency graphs for the seven parts of the spectrum used are given in Figures VIII–XIV. The size of the class interval for the vertical coördinate, representing the number of observers, is the same in all the curves. That along the horizontal coördinate differs according to the absolute value of the minimum visible in the particular color. Thus in red, where the value of the minimum visible is large, the interval is 400 (watt $\times$ 10^{-16}),

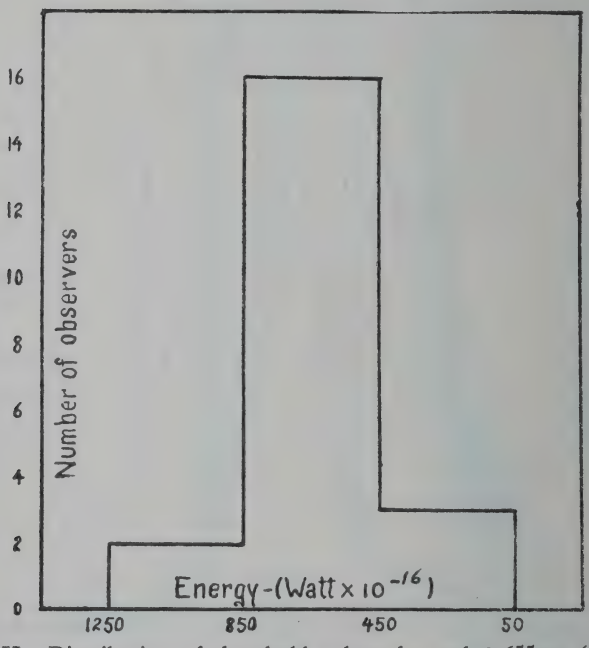


FIGURE VIII. Distribution of threshold values for red, λ 655 $\mu\mu$ (Table VI)

while in green it is only .8 (watt $\times$ 10^{-16}). The intervals were further chosen so that the median threshold value of the group in question would fall approximately at the center of some interval. Since the number of observers was small, it was thought that a truer picture of the distribution of values was obtained by the use of rather large intervals. As has been said, the frequency graphs are very nearly symmetrical—each shows a large average group and two smaller, almost equal groups, one superior, one

inferior to the average. Since this is true even for a small group, it seems reasonable to suppose that the same would be

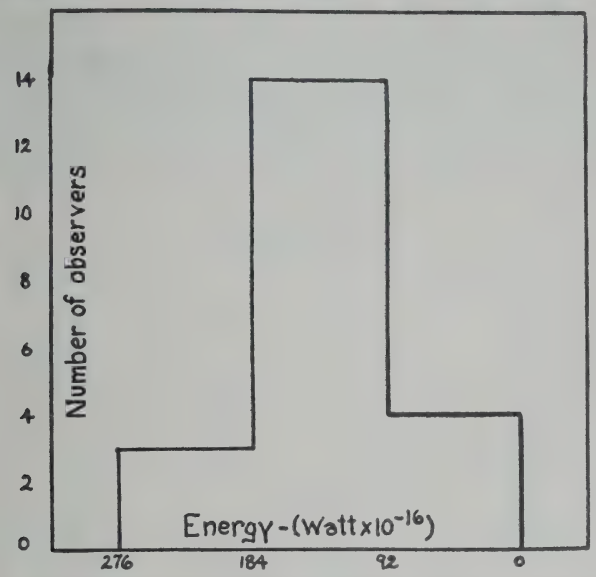


FIGURE IX. Distribution of threshold values for orange, λ 616 μμ (Table VI)

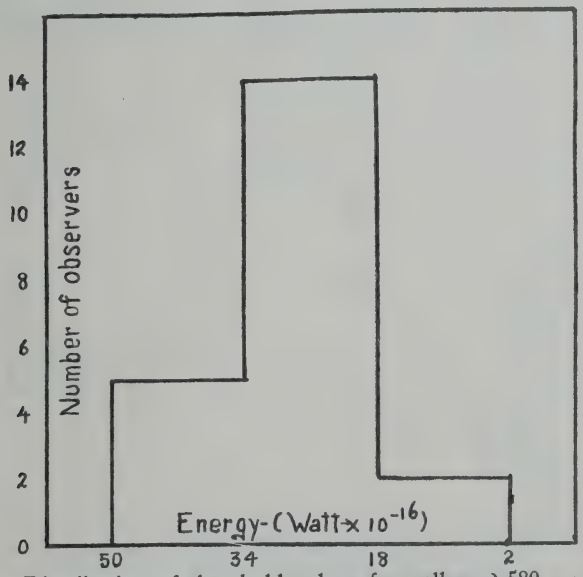


FIGURE X. Distribution of threshold values for yellow, λ 580 μμ (Table VI)

true for normal observers as a whole. In other words, it is probable that there is no uniform "normal" sensitivity to light of different wave-lengths, but a very wide range of sensitivity within which an individual threshold may be considered normal.

B. Chromatic Thresholds. It was originally hoped to determine the chromatic and achromatic thresholds of the seven wave-

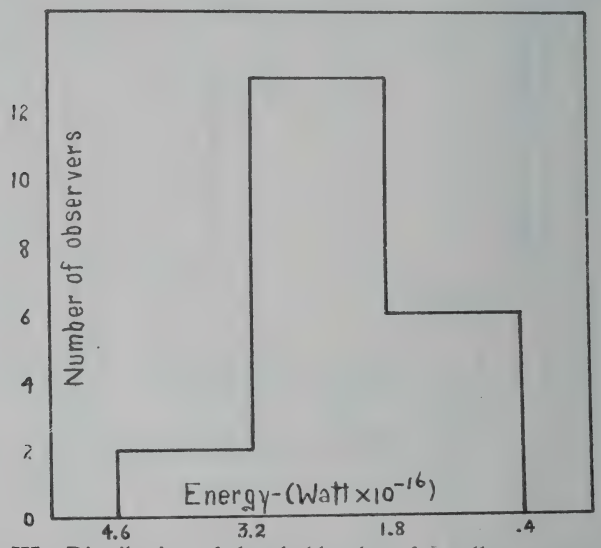


FIGURE XI. Distribution of threshold values for yellow-green, λ 553 μμ (Table VI)

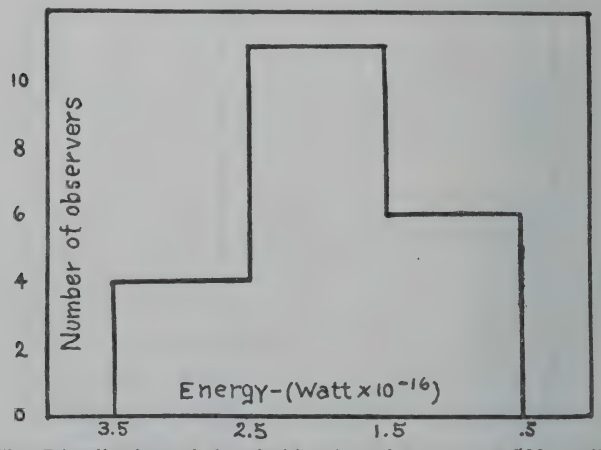


FIGURE XII. Distribution of threshold values for green, λ 522 μμ (Table VI)

lengths for the same observers. Most observers, however, were unable to give the time required for this, and comparison is possible, therefore, only between averages. The values of the chromatic thresholds obtained are given in Table VII. Since in only a few cases did the same observer determine the chromatic threshold for all seven wave-lengths, each column of Table VII gives the twenty-one values obtained arranged not according to

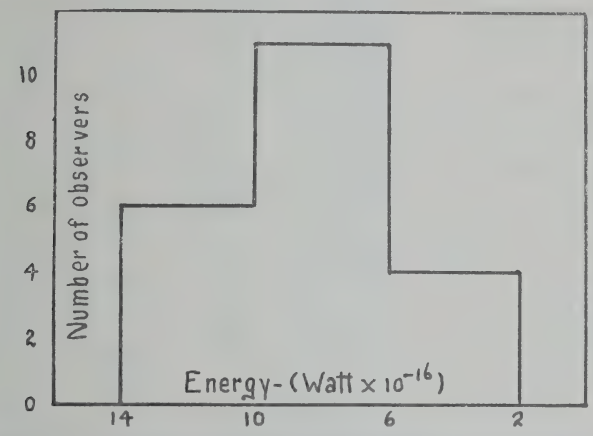


FIGURE XIII. Distribution of threshold values for blue-green, λ 489 μμ (Table VI)

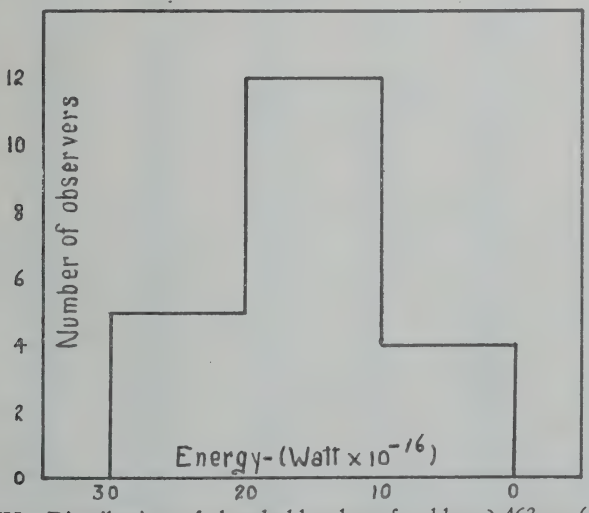


FIGURE XIV. Distribution of threshold values for blue, λ 463 μμ (Table VI)

observers, but according to order of magnitude. The results are presented graphically in Figures XV–XXIII.

The minimum visible—chromatic—for the different wavelengths used was found to be as follows:

1. Red (655 $\mu\mu$)	Average = .1778	watt × 10^{-12}
	Median = .159	"
	Range = .460 — .0597	"
2. Orange (616 $\mu\mu$)	Average = .562	"
	Median = .166	"
	Range = 3.11 — .054	"
3. Yellow (580 $\mu\mu$)	Average = 9.57	"
	Median = 4.32	"
	Range = 52.8 — .190	"
4. Yellow-Green (553 $\mu\mu$)	Average = .0856	"
	Median = .0127	"
	Range = .621 — .00771	"
5. Green (522 $\mu\mu$)	Average = .143	"
	Median = .0436	"
	Range = .603 — .0042	"
6. Blue-Green (489 $\mu\mu$)	Average = .643	"
	Median = .460	"
	Range = 3.16 — .0299	"
7. Blue (463 $\mu\mu$)	Average = .812	"
	Median = .329	"
	Range = 3.07 — .0298	"

TABLE VII

CHROMATIC THRESHOLDS

Amount of light enternig the eye (watt × 10^{-12})

No.	Red	Orange	Yellow	Yellow-Green	Green	Blue-Green	Blue
1.	.460	3.11	52.8	.621	.603	3.16	3.07
2.	.370	2.44	49.5	.413	.587	2.91	2.54
3.	.316	1.84	38.9	.299	.504	.986	2.48
4.	.301	.833	11.3	.0968	.401	.925	2.32
5.	.228	.820	8.57	.0959	.398	.714	1.32
6.	.188	.522	7.31	.0870	.0859	.548	1.14
7.	.171	.432	7.07	.0268	.0684	.504	.814
8.	.168	.242	6.09	.0148	.0493	.482	.566
9.	.167	.227	4.95	.0142	.0474	.473	.433
10.	.163	.170	4.61	.0130	.0449	.460	.355
11.	.159	.166	4.32	.0127	.0436	.460	.329
12.	.155	.163	.998	.0125	.0429	.366	.284
13.	.129	.149	.896	.0119	.0420	.351	.274
14.	.127	.135	.596	.0117	.0344	.343	.257
15.	.117	.118	.546	.0108	.0218	.321	.252
16.	.101	.0931	.519	.0107	.00818	.299	.233
17.	.100	.0859	.516	.0100	.00628	.0477	.213
18.	.0999	.0786	.516	.00959	.00497	.0473	.0574
19.	.0832	.0667	.463	.00890	.00449	.0404	.0425
20.	.0715	.0568	.461	.00853	.00420	.0321	.0392
21.	.0597	.0540	.190	.00771	.00420	.0299	.0298
Mean	.1778	.562	9.57	.08555	.14314	.643	.812
Med.	.1590	.166	4.32	.01270	.04360	.460	.329

The total range of the chromatic minimum visible of the wave-lengths used is therefore from 52.8 in the yellow to .0042 (watt $\times 10^{-12}$) in the green, a ratio from highest to lowest of 12571.

The average chromatic sensitivity is greatest in the yellow-green. The average threshold value for the yellow-green is

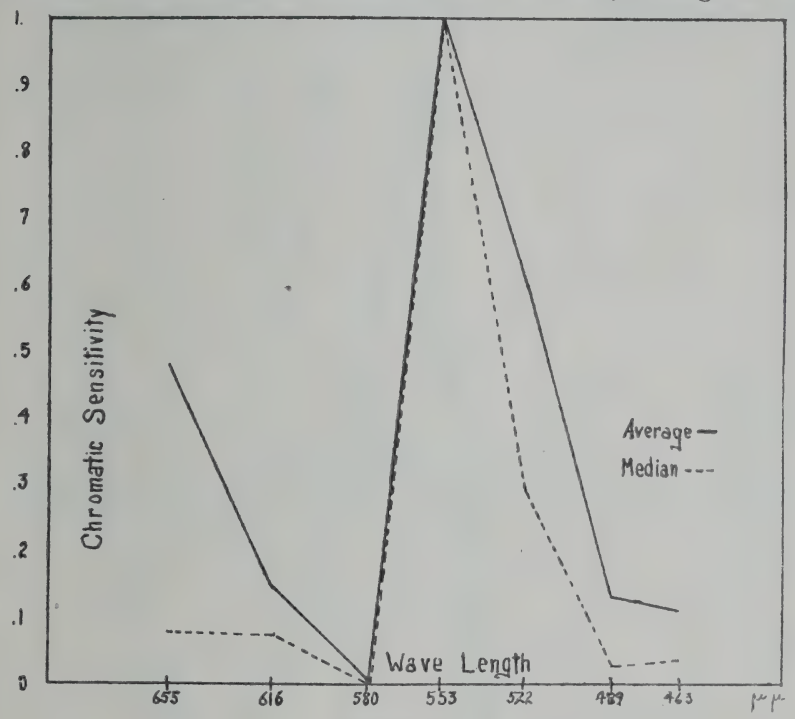


FIGURE XV

.08556 (watt $\times 10^{-12}$). The relative sensitivity to the other wave-lengths is best shown by Figure XV, which gives the mean and median values in the form of sensitivity curves. These curves were plotted in the same way as those in Figure VII. In both the mean and median sensitivity curves there is an extremely sharp drop from the yellow-green to the yellow. Since the chromatic thresholds for all colors were not determined throughout on the same observers, a composite of the individual sensitivity curves, similar to the composite of achromatic sensi-

tivity curves could not be made. All seven thresholds, however, were determined for six observers, and a composite of their sensitivity curves is given in Fegure XVI. There is much more variation in these curves than in those representing achromatic sensitivity. Four only have a maximum sensitivity in the yellow-green; of the other two, one shows a maximum in the green, the other in the blue. The relative sensitivity to the longer wave-

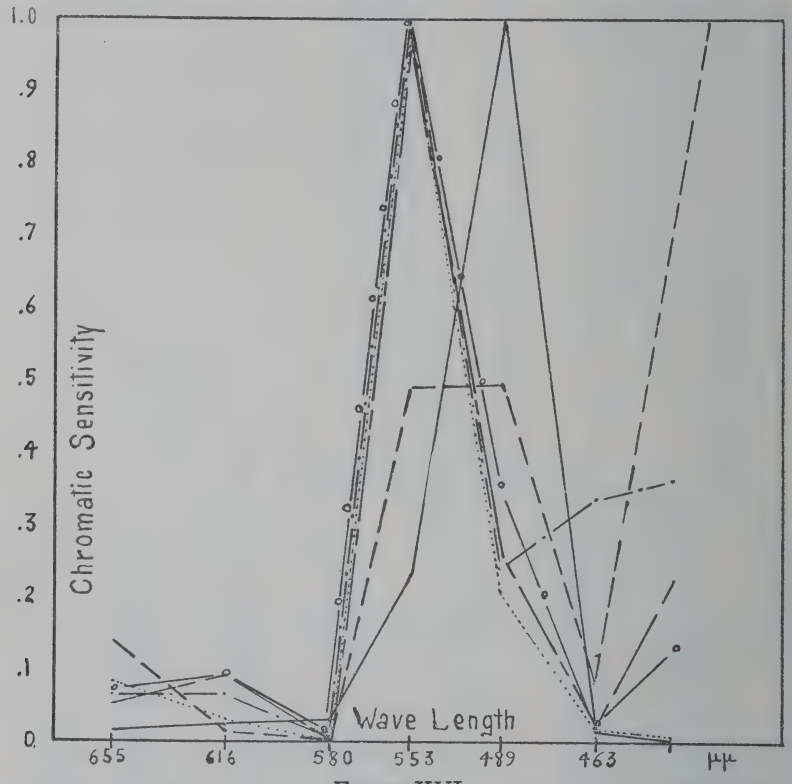


FIGURE XVI

lengths is more uniform—all six curves show the drop in the yellow, and all are fairly close together in the orange and red.

For the observers tested, the distribution of chromatic threshold values around an average is not symmetrical. In each color the threshold value of the median is much smaller than that of the corresponding average—that is to say, the curves are skewed to

the upper end. This means that the range of values below the median is much greater than that above the median. For instance, there is a difference of 48.48×10^{-12} watt between the

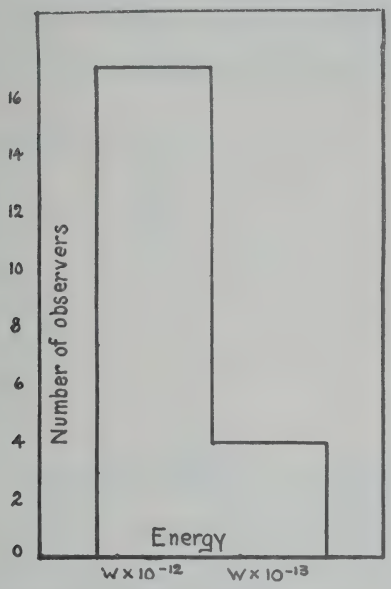


FIGURE XVII. Showing the threshold values for red, λ 655 μμ (Table VII)

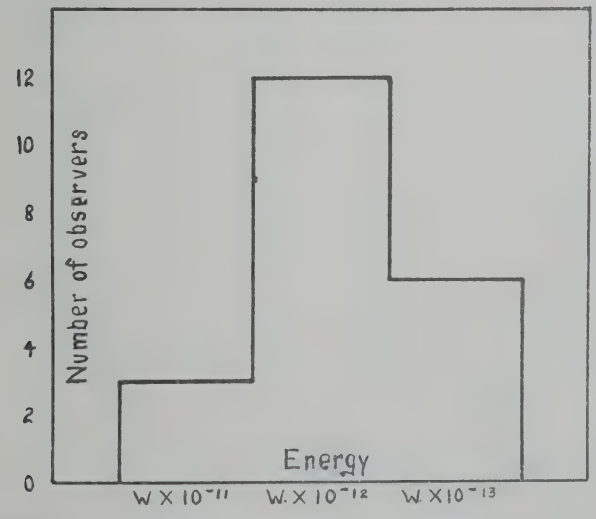


FIGURE XVIII. Showing the threshold values for orange, λ 616 μμ (Table VII)

median and the largest threshold in yellow, while there is a difference of only 3.13 between the median and the smallest threshold value in the same color. Because of this very wide range it was thought advisable to plot the logarithms of the energy values of

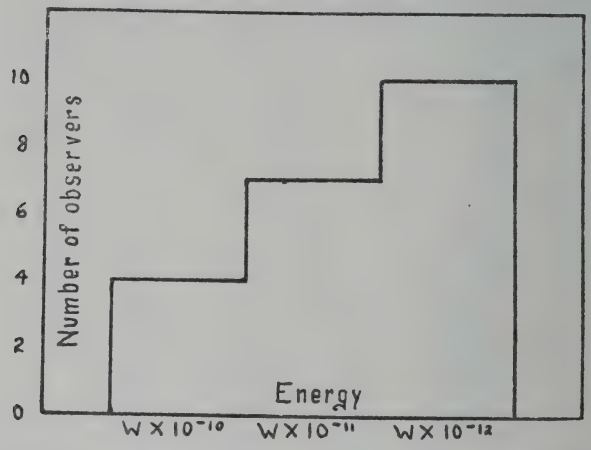


FIGURE XIX. Showing the threshold values for yellow, λ 580 μμ (Table VII)

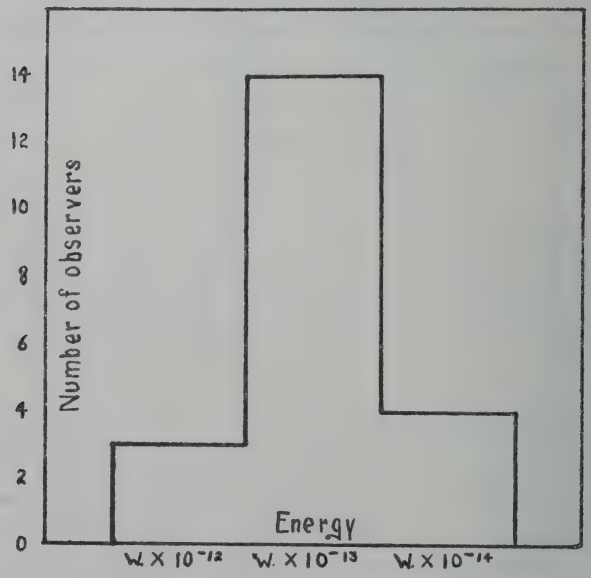


FIGURE XX. Showing the threshold values for yellow-green, λ 553μμ (Table VII)

the chromatic thresholds rather than the values themselves. Figures XVII–XXIII shows the frequency graphs of the seven wave-lengths. Along the ordinates is plotted number of cases. As in the curves for achromatic sensitivity, the class interval

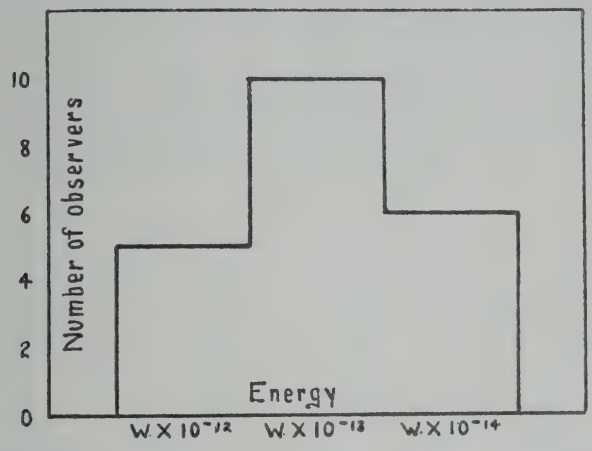


FIGURE XXI. Showing the threshold values for green, λ 522 μμ (Table VII)

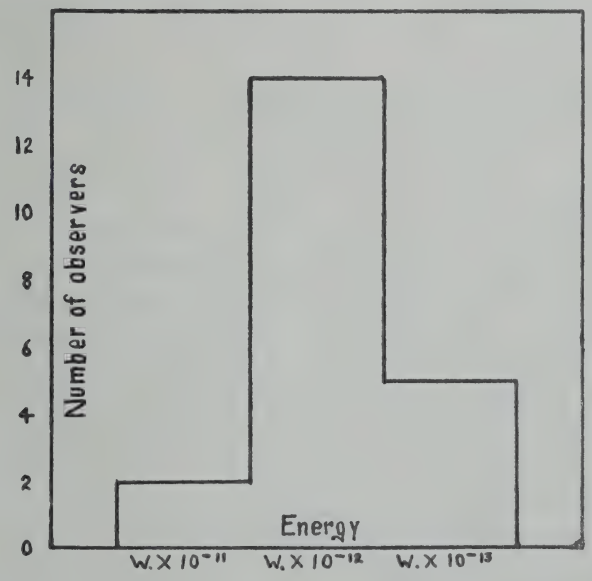


FIGURE XXII. Showing the threshold values for blue-green, λ 489 μμ (Table VII)

for the abscissae differs for the wave-lengths. Thus the first interval of the abscissa in blue-green, blue and orange contains all cases of the order 10^{-11} watt, the second interval all cases of the order 10^{-12} watt, and the third all cases of the order 10^{-13} watt. In green and yellow-green the intervals contain cases of the orders 10^{-12}, 10^{-13}, and 10^{-14} watt, respectively, and in the yellow 10^{-10}, 10^{-11}, and 10^{-12} watt.

It will be noted that the graphs of red and yellow differ from those of the other five wave-lengths by showing skewness even

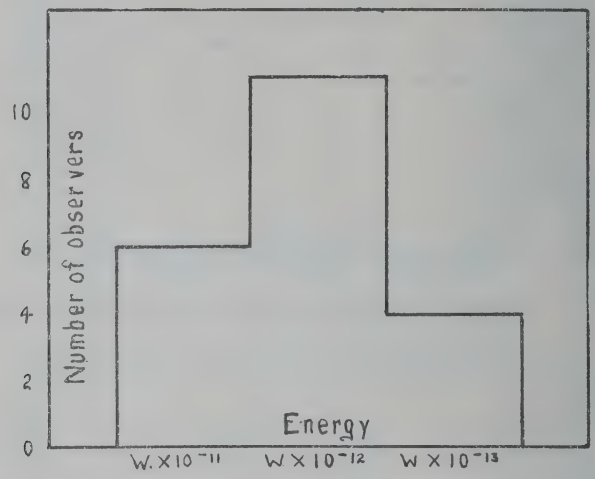


FIGURE XXIII. Showing the threshold values for blue, λ 463 μμ (Table VII)

in their logarithmic form. In red there is no inferior group—the values fall into a large average group and a smaller superior group. In yellow there is no superior group, but there is an additional very inferior group. It might seem reasonable to account for this on experimental grounds because of the difference in the abruptness with which the chromatic component comes into the sensation in the two cases. The chromatic threshold for red is by far the easiest to determine. The transition from achromatic to chromatic is abrupt and sharply marked and there is little or no hesitation on the part of the observer as to whether or not there is any color present. The ease of judgment resulting from this small and clearly defined transition interval probably

accounts for the absence of the inferior group. In yellow just the opposite condition obtains. The color comes in very slowly and gradually and the exact point of appearance of the chromatic component is difficult to determine. At low intensities light of wave-length 580 $\mu\mu$ has much the appearance of ordinary artificial light, such as that emitted by a carbon lamp, which an unpracticed observer is accustomed to consider as white. In such a case much greater intensities are needed for the light to be called colored. This may account for the additional very low group in yellow not found in any other of the colors.

C. The Photochromatic Interval. By the photochromatic interval is meant the colorless interval between the chromatic and the achromatic thresholds. In the present study the actual energy of both thresholds has been measured. This makes it possible to express the value of the photochromatic interval in absolute terms—terms that admit of a numerical comparison from wave-length to wave-length. Previous to this the photochromatic interval has been discussed only in the most general terms. Its existence, and the fact that it varied under different conditions, were noted by Tschermak (11), Fick (12), v. Kries (13), Hering (14), and others. There has been only one numerical statement of the value of the colorless interval between the two sets of thresholds, that of Charpentier in 1888 (15). Charpentier focussed light from the spectrum of the sun on ground glass, using the colored surface thus obtained as the stimulus for his determinations. The intensity was reduced by a diaphragm. No measurement, either photometric or radiometric, was made of the actual intensities used. The relation between the chromatic and achromatic thresholds was taken as equal to the ratio of the square of the diameters of the diaphragm openings necessary for the two thresholds at any given wave-length. The diameter of the opening required to reduce light in the yellow to the achromatic threshold was 1, the opening for the chromatic threshold of the same color was 3.1. The chromatic threshold is then, according to Charpentier, 9.6 times as large as the achromatic threshold. The ratios found are as follows:

Rouge extreme	3.6
Orangé	5.5
Jaune	9.6
Vert moyen	196.0
Bleu franc, région moyenne	635.0

The wave-length is not stated. Such ratios, obtained without reference to the absolute or even the relative intensity of the lights used, have little value other than to indicate that there is a photochromatic interval.

In 1892 Abney and Festing (16) determined the achromatic and chromatic thresholds throughout the spectrum and attempted to give a photometric evaluation to the results obtained. A monochromatic beam and a comparison white beam were so reflected as to fall on adjoining portions of a white screen. The chromatic thresholds were determined by reducing the intensity by means of a sectored disc introduced into the path of the monochromatic beam. Relative luminosity values were calculated by the use of a spectrum luminosity curve previously obtained. Relative luminosities, however, change with change in intensity of light, and this curve, while a low intensity curve, was not determined for threshold intensities. Achromatic thresholds were similarly determined, the relative luminosities of the different wave-lengths being calculated from the sectored disc values and the luminosity curve just mentioned. Abney and Festing did not, however, attempt to assign any values, either relative or absolute, to the photochromatic interval as such, and since their values for the thresholds are only relative, it is not possible to calculate it from their data.

The values of the photochromatic interval for the seven wavelengths used in this study are shown in Table VIII. Column 2 gives the energy value of the minimum visible achromatic, column 3 that of the minimum visible chromatic, and column 4 the difference between the two. In column 5 the values of column 3 are given in the form of ratios, the value for yellow being made equal to unity. The values are very large, ranging from 853.29×10^{-16} watt in the yellow-green to 95672.04×10^{-16} watt in the yellow. There is, apparently, a great difference between the development of the color sense of the eye and that of the light sense.

TABLE VIII

Wave length	Achromatic T. (watt $\times 10^{-16}$)	Chromatic T. (watt $\times 10^{-16}$)	Difference (watt $\times 10^{-16}$)	Ratio Yellow = 1
655 μμ	626.99	1778.00	1153.00	.01
616 μμ	130.28	5620.00	5489.72	.06
580 μμ	27.96	95700.00	95672.04	1.00
553 μμ	2.203	855.50	853.30	.009
522 μμ	1.953	1431.40	1429.45	.02
489 μμ	8.11	6430.00	6421.89	.07
463 μμ	15.62	8120.00	8104.38	.08

The value of the photochromatic interval throughout the spectrum is represented graphically in Figure XXIV. Along the

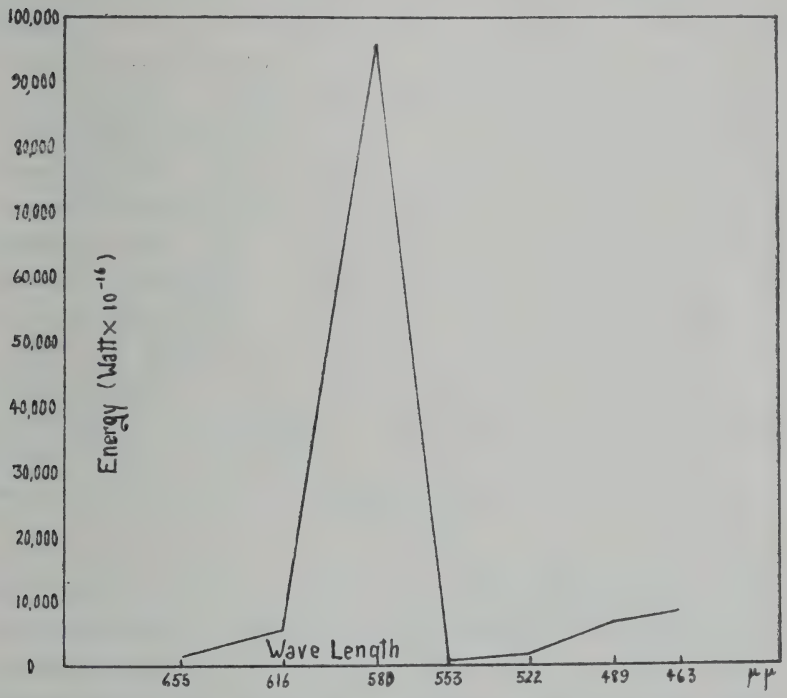


FIGURE XXIV. Showing value of the photo-chromatic interval (Table VIII)

vertical coördinate are plotted energy values (watt $\times 10^{-16}$). The resulting curve bears to some extent an inverse relation to the curve of chromatic sensitivity. Thus, the greatest chromatic sensitivity being in the yellow-green, the smallest photochromatic interval is in the yellow-green; similarly the largest photochro-

matic interval is in the yellow, to which there was the least chromatic sensitivity.

D. Comparison with Previous Determinations of the Threshold Visibility Curve. In section II is given a summary of various investigations that have been made of the relative sensitivity of the eye to lights of different wave-lengths. In no case was the apparatus and procedure identical with that employed in the present study, but it is, however, of interest to make the general

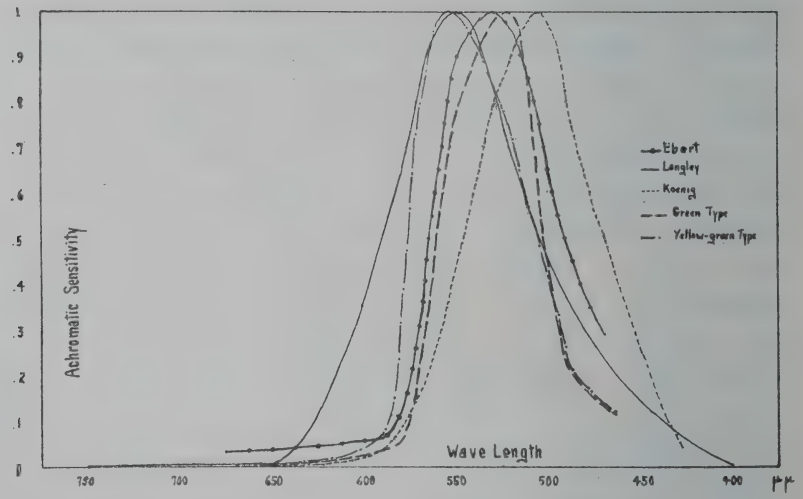


FIGURE XXV. Comparison of results of threshold visibility curve by various observers

comparison between such curves and the curves presented here. Figure XXV shows graphically a comparison of the results of Ebert, König, Langley, and the two types found in this experiment. In each case the maximum sensitivity was made equal to unity. The curve for Ebert represents the average relative sensitivity of two observers. It will be remembered that these two sets of results were very similar. König also gave values for only two observers, and these, too, have been averaged here, since they show comparatively small differences. The curve for Langley is plotted from the results of one observer. The range of maximum of the five curves is from λ 505 to 553 $\mu\mu$. König's

curve is shifted toward the blue end of the spectrum; Langley's curve, very similar to that of the "yellow-green type" found here, is shifted toward the red end. Ebert's curve and the curve of the "green type" fall between these two extremes. So different were the conditions of experimentation in each case that it would be futile to attempt to analyze disagreements. Difference in source, difference in number (and probably type) of observer, difference in methods of energy determination—any one of these would seem to be sufficient to account for the variation found. Indeed, it is surprising that there should be as much agreement as there is.

It will be noted that the results of Pflüger are not represented on this composite graph. The individual and diurnal variations in Pflüger's results were so large as to make averaging for the purpose of such a comparison impossible. The position of the maximum according to him ranges from λ 495 to 524 $\mu\mu$, and this deviation is found even in the results for a single observer—EI. A portion at least of this extreme variation can be explained. In the preliminary work of the present study the same difficulty obtained. It was soon found, however, that much of this diurnal fluctuation could be traced to physiological factors which could be controlled—at least in part. A cold, lack of sleep, or general fatigue changed the character of the results greatly—not only was the absolute sensitivity lessened, but the relative sensitivity was altered. Table IX gives the threshold values for the same observer taken on different days—once when much fatigued, the other when rested. In many colors the difference amounts to several hundred per cent. Besides being very insensitive, a fatigued observer is erratic, often makes entirely contradictory judgments, and is much more subject to troublesome after-images and idio-retinal light. Curiously enough, general fatigue was found to be more disturbing than eye strain. As has been stated in the section on apparatus and procedure, before making the final threshold determinations each observer was carefully questioned and a few trial settings made as a check on fatigue. It is believed that the influence of this factor on the final results is negligible.

TABLE IX

Condition	Red	Orange	Yellow	Yellow-Green	Green	Blue-Green	Blue
Fatigued	2257.94	676.25	48.67	4.618	4.558	16.00	19.04
Rested	305.71	135.42	14.38	1.622	1.718	7.79	13.00

E. The "Minimum Visible." In the work described in the preceding chapters the amount of light required to arouse both the chromatic and the achromatic response in different parts of the spectrum, the minimum visible for those wave-lengths has been measured directly in energy terms for the first time. As was pointed out in the historical section, the determinations of comparative sensitivity by Ebert, Pflüger, and others were made only in relative terms. Absolute values were not assigned to the light intensities on which the values were based. Moreover, in all cases but one the galvanometer deflections used in compiling the ratios were not obtained with the stimulus actually used in producing the eye's reaction.

Following a different line of development, however, attempts have been made to calculate the energy value of the minimum visible. The photometric and radiometric data used in making these calculations, however, were assembled from different sets of observations and experiments. One of the first of such estimates is that of Wien (17), who in his dissertation, "Ueber die Messung von Tonstärken," 1888, sought to compare the absolute sensitivity of the ear with that of the eye, his data on visibility being taken from the observations of the astronomers. He assumed that brightness of stars of the sixth magnitude could be taken roughly to represent the limit of visibility. By a comparison of available photometric and radiometric data he estimated the light from those stars to have an approximate value of 4×10^{-15} watt.

Drude (18), some eleven or twelve years later, calculating also from stellar data, obtained a smaller value for the minimum visible, 6×10^{-16} watt. He assumed the brightness of a star of the sixth magnitude to represent the limit of visibility, a brightness which he estimated to be equal to that of the Hefner lamp at 11,000 meters. Angström (19) had determined experimentally the energy value of the Hefner unit of illumination (the light

emitted in a unit solid angle, the lumen) to be 8.1×10^4 erg/sec. The relation of the unit of illumination to the unit of energy or power Drude called the mechanical equivalent of light. This relation of the photometric to the energy unit has been much employed by later investigators in attempts to arrive at approximate energy values from measurements made in photometric terms. The energy value of the lumen thus, in terms of the Hefner standard, would be 8.1×10^4 erg/sec., and the intensity of the illumination from a Hefner lamp at 11,000 meters would equal 1×10^{-8} lumens per square meter. Assuming further a pupillary opening of 3 mm., Drude calculated:

$$8.1 \times 10^{-8} \times .07 = .6 \times 10^{-8} \text{ erg/sec.} = 6 \times 10^{-16} \text{ w.}$$

This value of Drude has recently been recalculated by Coblentz (20), who had himself measured the total radiation of a Hefner lamp. Coblentz found the light density at 1 meter to be 7×10^{-8} g.cal. (or 29×10^{-8} w) per cm^2 per second. With this value the minimum visible would be:

$$\frac{29 \times 10^{-8} \times .07}{11000^2} = 1.7 \times 10^{-16} \text{ w.}$$

Another calculation of the least radiation visually perceptible from astronomical data is that of Ives (21). Ives, too, accepted the brightness of stars of the sixth magnitude as representing the minimum visible, but recalculated the photometric value of this brightness on the basis of later data on the relation of stellar magnitude to the candlepower scale. He also used a different value of the mechanical equivalent to convert the photometric into radiometric terms. Drude had based his determination of the mechanical equivalent on the lumen as representing the total radiation in a solid angle from the Hefner standard. Ives used the lumen to represent the photometric unit of radiation from the region of the visible spectrum to which the eye is the most sensitive, taken from previous determinations of the relative sensitivity of the eye to wave-length. These determinations, however, were not made at threshold intensities. If the minimum visible be taken to represent the least amount of radiation visually percep-

tible, of wave-lengths to which the eye is most sensitive, the lumen selected by Ives is the more compatible with the purpose of the problem. However, the light selected by Drude on which to base the ratio of the photometric to the radiometric unit is more nearly of the same composition as the light used to produce the eye's reaction. Both methods are in error, but on different points. Obviously if the minimum visible is to be determined in absolute units for the wave-lengths to which the eye is most sensitive, these wave-lengths should be used to determine the threshold of sensation and the energy value of the light should be measured directly. Using .00159 as the lumen value in watts, Ives made the following calculation:

1 meter-candle = 1 lumen per sq. meter = 0.0001 lumen per sq. cm. = .000000159 watt per sq. cm. = 1.59 ergs per sec. per sq. cm.

The meter-candle value of a star of the sixth magnitude had been found by Russell to be 0.849×10^{-8}. Ives, adopting this value, obtained

$$1.59 \times 0.849 \times 10^{-8} \text{ w} = 1.35 \times 10^{-8} \text{ erg/sec.}$$

Assuming a 6 mm. pupillary opening instead of a 3 mm. opening, the minimum visible would equal

$$.38 \times 10^{-8} \text{ erg/sec.} = 38 \times 10^{-17} \text{ w.}$$

Russell (22), supplementing the work of Ives, adopted the same method of calculation, but used what he thought to be more correct figures for the breadth of the pupillary aperture and the stellar magnitude of the faintest visible object. He accepted the pupillary value of 8.5 mm. proposed by Steavenson and a stellar magnitude of 8M.5. The resulting minimum visible was 7.7×10^{-17} w.

The above method of calculating by means of stellar data and the mechanical equivalent has been varied by the use of an artificial star. In this way the photometric determination of the threshold can be made experimentally, thus avoiding to some extent the uncertainties of stellar observations. Buisson (23) measured the distance at which phosphorescent screens of different

sizes could just be seen. The brightness of the screen was then transmuted into the stellar magnitude scale. Using the same values for the mechanical equivalent and pupillary aperture as did Ives, he found the minimum visible to be 12.5×10^{-17} w. Reeves (24) used the transmitted light of a modified Nutting sensitometer, the intensity of which could be controlled. The source of light was a tungsten lamp. He also measured the pupils of his observers instead of taking a standard average value. With a visual angle of 1.17 (1 mm. star at 3 meters), the total energy entering the eye at threshold intensity was calculated to be 19.5×10^{-17} w. (mean of three observers). The mechanical equivalent was taken equal to .00159 watt per lumen.

Among the investigation in which some magnitude of star is assumed as the limit of visibility, direct energy measurements of that source have been made only in one case. Coblentz (20) assumed stars of the sixth magnitude to have the least visible brightness and measured directly the visible radiation from these stars. He states his procedure briefly as follows: "The sensitivity of the eye may be estimated—from direct measurements of the heat from stars. The calibration of the radiometer was 1 mm. deflection $= 34 \times 10^{-14}$ g.-cal. per cm.^{2} per minute $= 85.5 \times 10^{-16}$ w. per cm.^{2} per second. The sixth magnitude stars gave deflections of 0.5 mm. for blue stars to 1.5 mm. for red stars (say, 1 mm. on an average), depending on their color. From measurements made on the transmission of stellar radiation through a cell of water the radiant luminous efficiency may be 0.2 (0.1 for red stars to 0.4 for blue stars). Hence the luminous energy intercepted by a pupillary opening of 0.07 cm.^{2} is $(85.5 \times 10^{-16} \times 0.2 \times 0.07) = 1.2 \times 10^{-16}$ w." Here, then, is a direct radiometric measurement of the source—there is, however, no corresponding direct determination of the threshold.

The above summary of work done by previous investigators shows disagreement both as to procedure and as to what shall be called "the least radiation visually perceptible" or "the minimum visible." Lights differing greatly in composition have been used, spectrum and approximate white; and with one exception the energy value has been calculated indirectly from measurements

made on some other source or computed by the use of a mechanical equivalent which expresses the relation of the photometric to the energy unit for some other source than the one used for the visual stimulus. And in case of this one exception the limit of visibility was taken from astronomical data on the visibility of stars, the estimates of which range from the sixth to the eighth magnitude, rather than having been experimentally determined.

It would seem reasonable to assume that *the* minimum visible should mean the least amount of radiation visually perceptible of the wave-length or range of wave-lengths to which the eye is the most sensitive measured in absolute units. So defined, the essential conditions for its determination would be a careful search of the spectrum for this wave-length to which the eye is the most sensitive, a determination of the limit of visibility with this wave-length, and the direct measurement of its energy. In the investigations cited above, one and sometimes two, but never all of these conditions, have been satisfied. Moreover, in no case, whatever the source of light chosen, has the energy been measured and an actual determination of the limit of visibility been made for the same light.[1]

[1] By a still more rigid interpretation the determination of the minimum visible might also involve the satisfying of other and more difficult requirements such as the use of the most favorable time of exposure and size of field, the use of the most sensitive part of the retina, etc., all of which features would in all probability differ in value both for the wave-length of light employed and for the observer. Von Kries and Eyster (25) sought to determine the achromatic threshold not only with the wave-length to which the eye is most sensitive but also under the most favorable conditions of time of exposure, size of field and portion of the retina used. Their selection of 507 $\mu\mu$ as the proper stimulus to use was apparently based not on a determination of their own of relative sensitivity but primarily on the fact that Trendelenburg had found that this part of the spectrum gave the maximum bleaching of the visual purple. According to the Düplicitäts theory the wave-length that would give the maximum bleaching of the visual purple should be theoretically the most correct. Also this wave-length fell within the range to which König had found the eye to be the most sensitive for a group of observers. Their description of procedure leaves one in doubt whether the long and exceedingly difficult systematic survey was made which would be needed to determine what part of the retina is the most sensitive to the light in question, and what is the optimum size of field and time of exposure. The statement is made that the periphery of the retina was used and that several sizes of field and times of exposure were used, but no information is given

The determination of the minimum visible has been by no means the purpose of the present investigation. The energy values of the achromatic and chromatic thresholds have been determined for seven representative parts of the spectrum. There has not been a graded, minute search for the wave-lengths to which the eye is the most sensitive. However, two of the points used, 522 $\mu\mu$ in the green and 553 $\mu\mu$ in the yellow-green, fall within the range of wave-lengths to which previous investigators have found the eye to be the most sensitive at threshold intensities for different types of observers. To this extent the requirement that in the determination of the minimum visible the wave-length should be used to which the eye is the most sensitive at the threshold intensities has been satisfied; the other requirement, that the energy measured should be of the light used to produce the eye's reaction, has been fully satisfied. It would seem then that our results are entitled to consideration together with those purporting to represent the minimum visible, although such a determination formed no part of the original purpose and its relation to the present work came out only in a study of the results obtained.

A brief summary of the various values that have been obtained is given in Table X in order that the values of previous investigators may be more conveniently compared with those obtained here. The apparent closeness of agreement of the results

as to the approximate meridian or degree of eccentricity of the area of the retina stimulated. The source of light was a Hefner lamp the radiations from which were reflected from a magnesium oxide surface into a spectroscope. The energy values were calculated from Angström's data on the distribution of energy in the light from a Hefner lamp. Von Kries sums his conclusions as follows:

"1. Für eine merkliche Erregung des Sehorgans ist bei Herstellung der günstigsten Bedingungen hinsichtlich Adaptation, Strahlungsart (507 $\mu\mu$) räumlicher und zeitlicher Verhältnisse eine Energiemenge von 1,3–2,6 $\times$ 10^{-10} Erg. erforderlich.

"2. Für die Sichtbarkeit dauernd exponierter Objekte ergibt sich bei günstigster Strahlungsart und güstigster räumlicher Anordnung eine Energiezuführung von ca. 5,6 $\times$ 10^{-10} Erg. pro Sekunde."

Boswell (26) repeated the experiments of von Kries and Eyster, using an amyl acetate lamp as source and the fovea rather than the more sensitive peripheral retina. He calculated the minimum visible to be 23.7 $\times$ 10^{-17} watt.

obtained may not at first glance seem compatible with the rather wide disagreement in plan and method of making the determinations. On this point, however, two comments may be made: (a) The percentage disagreement is not small, and (b) a great deal of disagreement is doubtless masked by the insensitivity of the instrument used to measure the energy values as compared with the eye. Coblentz (20), for example, has estimated the eye to have 300,000 times the sensitivity of the thermopile.

TABLE X

Wien	40.00×10^{-16}w	Reeves	1.95×10^{-16}w
Drude	$6.00 \times$ "	Von Kries	$.20 \times$ "
Drude-Coblentz	$1.70 \times$ "	Boswell	$2.37 \times$ "
Ives	$3.80 \times$ "	(Present study)	
Russell	$.77 \times$ "	Average (553 μμ)	$2.56 \times$ "
Buisson	$1.25 \times$ "	Average (522 μμ)	$2.30 \times$ "
		Smallest value	$.64 \times$ "

F. Pathological Cases. The importance of light and color sense testing as an aid to diagnosis in pathological conditions of the eye is well recognized. There has been, however, little or no quantitative study along this line. Although the present apparatus is, of course, unsuited to clinic work, it was thought of interest to determine the achromatic and chromatic thresholds to certain wave-lengths in a few typical pathological cases.

The following patients were sent me by Dr. Luther C. Peter, Associate Professor of Ophthalmology, Philadelphia Polyclinic and College for Graduates in Medicine, University of Pennsylvania, whom I wish to thank for his kindness both in coöperating in the finding of suitable cases and in furnishing the history of each case.

CASE I

Mr. Charles P., age fifty-six, cabinet maker. Chief complaint dimness of vision. Has been a heavy user of tobacco and alcohol. Vision O D = 20/100, O S = 20/150, plus correction = 20/40 partly in the right and 20/70 in the left eye, now corrected to 20/40 in each eye.

Fundus shows atrophic condition of the optic nerves with low grade retinitis. Fields are considerably contracted for colors, and both blind spots are enlarged for both form and color.

Diagnosis: Toxic amblyopia (tobacco and alcohol); papillo-macular bundle is undoubtedly involved in the toxemia.

Toxic amblyopia—weak vision due to chronic toxemia—may be brought on by any toxic agent, but its chief causes are tobacco

and alcohol, either singly or combined. Samelsohn, according to Fuchs (27), was the first to discover the anatomical changes that take place in the disease. "He showed that they were limited to the papillo-macular bundles, whose position and course within the optic nerve he was thus able to determine. In the course of this bundle it is found that the nerve fibers have disappeared and nothing but glia tissue is present, while the connective-tissue septa lying between the nerve fibers are thickened. Samelsohn regarded this as the outcome of an interstitial inflammation of the optic nerve, the inflammation affecting the connective tissue portion and especially the septa which convey the blood vessels and which because of the inflammation become thickened. Others, however, think that thickening of the connective tissue is a primary lesion of the optic-nerve fibers by the poison, and that if a thickening of the connective-tissue septa was found, this was a secondary change. Lastly, there are some who believe that even the destruction of the nerve fibers is not the primary affection, but that, in analogy with the conditions of acute poisoning (by quinine, etc.), this consists in a lesion of the ganglion cells in the retina and that an ascending atrophy develops in the nerve fibers as a secondary affair."

The values of the chromatic and achromatic thresholds obtained are given in Table XI. The loss of sensitivity for both color and light sense is very great. The loss is not, however, uniform throughout the spectrum—there is much irregularity shown from wave-length to wave-length. The extremely insensitive reaction to blue (right eye) and red (left eye) is particularly noticeable.

TABLE XI

TOTAL AMOUNT OF LIGHT ENTERING THE EYE (Mr. Charles P.)

Color		Right	Left	Average (Normal)
A. Achromatic Thresholds (watt $\times 10^{-16}$)				
Red	(655 $\mu\mu$)	3754.76	1101394.80	626.99
Yellow	(580 $\mu\mu$)	433.73	4888.48	27.96
Green	(522 $\mu\mu$)	27.64	34413.28	1.953
Blue	(463 $\mu\mu$)	61695.27	2789.47	15.62
B. Chromatic Thresholds (watt $\times 10^{-12}$)				
Red	(655 $\mu\mu$)	.332	297.640	.178
Yellow	(580 $\mu\mu$)	86.530	9.406	9.570
Green	(522 $\mu\mu$)	3.820	74.140	.143
Blue	(463 $\mu\mu$)	156.440	201.430	.812

CASE II

Ruth L., age thirty-eight, single, housework. Bilateral glaucoma when twenty-eight years of age. Present condition of the right eye—phthisis bulbi and blind. Left eye — vision = 20/15 partly. The left eye was operated on twice, first operation about eight years ago, an iridectomy; second operation sclero-corneal trephining about eight months ago. Tension normal.

Fields show some contraction for both form and color. Up and to the nasal side of the field is a large angular scotoma extending from and including the blind spot of Mariotte to the periphery including about 1/6 of the circumference of the field. The blind area passes in a horizontal line above the point of fixation. The macular fibers are not involved by the pathologic process in so far as clinical methods can determine.

Diagnosis: Chronic congestive glaucoma; partial loss of the upper nasal field.

The threshold values for the left eye are given in Table XII. Chromatic sensitivity is normal and the achromatic threshold for green is normal; the achromatic sensitivity to red and blue, however, is very low. The threshold values for yellow were not determined, as the eye fatigued rapidly.

TABLE XII

TOTAL AMOUNT OF LIGHT ENTERING THE EYE (Ruth L.)

Color		Left	Average (Normal)
		A. Achromatic Thresholds (watt $\times 10^{-16}$)	
Red	(655 $\mu\mu$)	2871.54	626.99
Green	(522 $\mu\mu$)	3.32	1.953
Blue	(463 $\mu\mu$)	70.15	15.62
		B. Chromatic Thresholds (watt $\times 10^{-12}$)	
Red	(655 $\mu\mu$)	.287	.178
Green	(522 $\mu\mu$)	.407	.143
Blue	(463 $\mu\mu$)	.687	.812

CASE III

Mr. Wm. A. M., age fifty-one, carpenter. Eyes have been failing for seven years. Hypermature cataract in the right eye, incipient cataract in the left. In addition the patient is suffering from bilateral sclerosis of the choroid. Patient has tubular vision in the left eye, 20/30 partly, central vision, improved to 20/20; vision now reduced to 20/40. Light perception only in right eye. Form fields are reduced to 10° in the left eye, and red and green varies from between 5° and 7°. Light perception and light projection is feebly present to the extent of 20°. Wassermann is positive. Clinical diagnosis—sclerosis of the choroid and incipient cataract.

The threshold values obtained are given in Table XIII. Both eyes are much below normal, the right more so than the left, as would be expected. In this case again the relative sensitivity is quite different from that of the normal eye—sensitivity to blue

being disproportionately low. The chromatic responses are most erratic, although they approach the normal more nearly than do the achromatic. In these, too, is shown the great loss of sensitivity to blue.

TABLE XIII

TOTAL AMOUNT OF LIGHT ENTERING THE EYE (Mr. W. A. M.)

A. Achromatic Thresholds (watt $\times 10^{-16}$)

Color		Right	Left	Average (Normal)
Red	(655 $\mu\mu$)	164307.31	35229.61	626.99
Yellow	(580 $\mu\mu$)	496082.50	5969.26	27.96
Green	(522 $\mu\mu$)	61211.66	7651.46	1.953
Blue	(463 $\mu\mu$)	3759525.00	1051104.50	15.62
		B. Chromatic Thresholds (watt $\times 10^{-12}$)		
Red	(655 $\mu\mu$)	12.63	3.52	.178
Yellow	(580 $\mu\mu$)	*	*	9.570
Green	(522 $\mu\mu$)	9.29†	1.17†	.143
Blue	(463 $\mu\mu$)	463.84	158.49	.812

* Yellow was called colorless even at full intensity.
† Green was always called blue, no matter how high the intensity.

CASE IV

John H., age sixteen. Secondary atrophy of the optic nerve following injury to the orbit by an automobile. Vision O D = 20/20 partly, O S = 20/70. This has since been reduced to 20/500 in the left eye. The ophthalmoscope shows a white nerve head with much contraction of arteries and veins. The form field is reduced to about 10° and green is visible 3° beyond the point of fixation (by clinical methods of study).

Clinical diagnosis: Progressive secondary optic atrophy (traumatic).

The energy values for the achromatic thresholds cannot be given—both eyes fatigued very rapidly, and as the first rough settings showed that the threshold values would fall well within the normal range, the more accurate determination was not undertaken. The chromatic thresholds values for the injured eye are given in Table XIV. Sensitivity to green and blue is normal; sensitivity to red is greatly reduced.

TABLE XIV

TOTAL AMOUNT OF LIGHT ENTERING THE EYE (John H.)

Chromatic Thresholds (watt $\times 10^{-12}$)

Color		Left	Average (Normal)
Red	(655 $\mu\mu$)	1700.00	.178
Green	(522 $\mu\mu$)	.653	.143
Blue	(463 $\mu\mu$)	.106	.812

CASE V

John B. H., age twenty-three, student. Convergent unilateral squint since early childhood. Vision without glasses: O D = 20/500, O S = 20/300. Vision

with glasses: O D = 4.50 S O .25 C ax 90 = 20/300, O S = 4.00 S O .50 C ax 90 = 20/12. Right eye shows convergent squint of 20°. Peripheral vision good; macular vision in the squinting eye amblyopic.

Diagnosis: Amblyopic ex anopsia as the result of the squint.

Amblyopia ex anopsia—defective vision attributed to lack of use—" may occur on account of obstruction to the rays of light falling upon the retina—*e.g.*, congenital corneal opacities, congenital cataract, and impervious persisting pupillary membrane; or in an eye which from early infancy has squinted, and has, therefore, not been concerned in the visual act." Parker (28) gives the following description of the process: " Because of defect in the fusion faculty, aided, perhaps, by hypermetropia (far-sightedness) and possibly from debility from disease, one eye shows an occasional transitory squint. This at first produces a diplopia (double images) from the fact that the two images do not fall on corresponding spots of the retinae. The eyes right themselves by muscular effort to parallelism to avoid this diplopia, but this power is soon lost, and the image of the squinting eye is suppressed, at first much as we would suppress the images falling on the left retina when we are looking through a microscope with the right eye; finally the squint becomes constant, diplopia no longer is noticed, and the retina of the squinting eye ceases to functionate. This condition is properly called *amblyopia ex anopsia.*"

As is shown in Table XV, both the light and color sense of the defective eye were found to be normal. This is what was expected by Dr. Peter, who believed it to be a matter of defective spatial perception.

TABLE XV

Total Amount of Light Entering the Eye (John B. H.)

Color		Right	Average (Normal)
		Achromatic Thresholds (watt $\times 10^{-16}$)	
Red	(655 $\mu\mu$)	560.00	626.99
Yellow	(580 $\mu\mu$)	26.46	27.96
Green	(522 $\mu\mu$)	3.811	1.953
Blue	(463 $\mu\mu$)	16.48	15.62
		Chromatic Thresholds (watt $\times 10^{-12}$)	
Red	(655 $\mu\mu$)	.17	.178
Yellow	(580 $\mu\mu$)	4.68	9.570
Green	(522 $\mu\mu$)	1.219	.143
Blue	(463 $\mu\mu$)	2.102	.812

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AN EXPERIMENTAL STUDY OF SOME BEHAVIOR TRAITS OF THE POTENTIALLY DELINQUENT BOY

A THESIS

SUBMITTED TO THE DEPARTMENT OF PSYCHOLOGY AND THE COMMITTEE ON GRADUATE STUDY IN THE LELAND STANFORD JUNIOR UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

BY

ALBERT SYDNEY RAUBENHEIMER

MAY, 1923

P.R.M.
v.34

ACKNOWLEDGMENT

With the completion of this study I wish to express my indebtedness to Dr. Leta S. Hollingworth and Dr. E. L. Thorndike of Teachers College, Columbia University, for introducing me to psychological methods of studying educational problems. They also made it possible for me to accept the Buckel Fellowship at Stanford University, so as to enable me to work under the direction of Dr. L. M. Terman at that institution.

I am especially obligated to Dr. T. L. Kelley and Dr. L. M. Terman of Stanford University for providing the facilities for the development of my study and for their direction, criticism, and guidance.

As a foreign student in America I cannot but express my sincere appreciation for the generous consideration that was given me at all times by the university authorities both at Teachers College, Columbia University, and at Stanford University.

This study has, in part, been made possible because of help received from the Stanford Commonwealth Fund.

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CHAPTER I

INTRODUCTION

1. *Statement of the Problem:*

The purpose of this study was to attempt to devise a method of analysis whereby some of the delinquent tendencies in boys could be determined prior to the overt expression of such tendencies, or rather, before the crystallization of such tendencies and desires into permanent habits of thought and action.

Because of the baffling complexity of the many factors that influence the development of human behavior, and because of the almost total absence of reliable experimental methods for the study of personality (when intelligence testing is excluded), it must be stated at once that the development of a method that would yield a reliable and valid diagnosis and prognosis for the *individual* was beyond the aim and possibility of the present study. The immediate aim was rather the development of experimental methods of differentiation between groups that are known to be stable, healthy-minded, reliable, and truthful (according to the present standards of the school and of society in general), groups that are less stable, healthy-minded, reliable, and truthful, and those that have already become special charges to society, because of their social maladjustment. It is only after such a method of differentiation on a broad, though defined, basis has been established, that a more detailed experimental analysis of the factors that are prophetic of delinquency within the individual can be undertaken. Of course, it might not be overdaring to hope that even this method of differentiation on broad lines might reveal some of the detrimental factors at work with particular individuals. That, however, is of secondary concern in this study.

2. *Review of Experimental Studies of Delinquent Development:*

The problem of delinquency is but a part of the larger problem of human behavior and adjustment. The study of the nature and

causes of delinquent development has, therefore, gone hand in hand with the analysis of character and character development in general.

For a résumé of the literature of character study in broad outline it might be well to refer to a recent publication of Cady.[1] He lists some of the more important discussions and studies of personality under three rubrics:

> " I. General studies in character and personality, normal and abnormal.
>
> " II. Lists of traits and their classification; trait rating; systematic observation of personality; statistical methods relative to rating.
>
> " III. Tests and test batteries for the estimation of character traits or personality as a whole."

His résumé is not a complete one; and such studies as those of Galton,[2] Heymans and Wiersma,[3] Westermark,[4] Dewey,[5] Ach,[6] and Stern [7] should be included.

When the literature concerned with studies of delinquency is more specifically taken in review, one fact becomes very pronounced, viz., that almost no experimental methods have been developed for the early detection of delinquent behavior. Practically all of the studies have been of a historical or biographical nature, " post-mortem " analyses of the conditions that were or may have been instrumental in bringing about the development. These studies have undoubtedly been extremely desirable and

[1] Cady, V. M. The Psychology and Pathology of Personality. *Jour. of Delinquency,* Vol. VII, No. 5, 1922.

[2] Galton, Francis. *Inquiries Into Human Faculty and Its Development,* 1883.

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[4] Westermark, E. *The Origin and Development of the Moral Ideas,* Vol. I and II, London, 1906.

[5] Dewey, John. *Human Nature and Conduct.* Henry Holt & Co., New York.

[6] Ach, N. *Ueber den Willensakt und das Temperament,* 1910.

[7] Stern, W. *Die differentiele Psychologie in ihren methodischen Grundlagen,* 1911, Leipzig.

necessary before any analysis of potentially delinquent behavior could be undertaken. The following are some of the contributing causes that have been studied:

a. *Physical and Physiological Factors:* While Healy [8] recognizes the influence that an enfeebled physical constitution may have in the general development of action and thought, he holds that physical measurements are inadequate and unsound as a means of diagnosing delinquency. Kelley [9] took very careful measurements of the inmates of the Texas State Juvenile Training School and came to the conclusion "that the delinquent boy . . . lies near the 55 percentile in his physical being exclusive of his physiological development, the 40 percentile in his sensory and psychomotor" powers. He recognizes with Goring [10] the diagnostic value of psychomotor and sensory tests because of the handicap placed upon the defective individual in making the necessary complex adjustments. Goring claims that the criminal is in the main a defective individual. Burt [11] claims that "measured by the coefficient of association the connection between delinquency and physical defect in general seems relatively small."

b. *Mental Factors:* The mental aspects of delinquency have been studied more thoroughly and scientifically than any other contributing factor. This has been made possible through the derivation of reliable test methods. Since the development of the Binet tests of mental ability by Goddard, Terman, Kuhlmann, Bobertag, Burt, and others, into a reliable instrument of mental measurement, numerous studies have been made of the mental make-up of delinquents. While the important relationships between mental endowment and social adjustment is thoroughly recognized by students of the subject, there is by no means

[8] Healy, William. *The Individual Delinquent.* Little, Brown & Co.. 1915.
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unanimous agreement between them as to the approximate measure of association.

Healy [12] states, "if, as usually reckoned, all having an I.Q. below 70 are pretty surely feebleminded, then 7 per cent of the total number belong in that category." Goddard's [13] findings varied all the way from 72 per cent for delinquent girls to 25 per cent for children who are court charges. Such extreme differences might perhaps be explained on the basis of difference of selection. Then, too, Goddard's examinations were made with the earliest revisions of the Binet Scale. Since 1912 the scale has been considerably improved. Kelley (study quoted previously) estimates that "20 per cent of the boys at Gatesville would better be in schools for the feebleminded," and he adds that "50 per cent of delinquents are totally incapable of being taught to look after themselves in an environment as unfavorable as the one from which they came." Fernald [14] reports that 25 per cent of 100 prisoners at the Massachusetts State Reformatory were feebleminded, and that the proportion amongst the juvenile court charges must be still higher. Williams [15] concludes after a study of 470 cases that "approximately 30 per cent of the delinquent and dependent boys included in this investigation are definitely feebleminded." Burt, in the study referred to previously, maintains that of the delinquent boys he was studying "nearly 10 per cent owed their delinquency primarily either to general mental deficiency or natural dullness not amounting to definite deficiency"; and in a further 25 per cent "dullness or deficiency appears as a subordinate factor." He goes on to state that "delinquency depends much more closely upon emotional con-

[12] Healy, William. *The Practical Value of Scientific Study of Juvenile Delinquents.* U. S. Dept. of Labor, Bull. No. 96, 1922.

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ditions than upon intellectual conditions, although it is the intellectual status of the delinquent that has hitherto monopolized the main interest of criminal psychology."

Numerous other studies can be added to those mentioned above. These, however, are sufficiently representative for an appreciation of the methods and findings of mental tests in their relation to the study of delinquency.

c. *Social and Environmental Factors:* The idea that delinquency, as such, is hereditary, is no longer generally maintained. Factors that are instrumental in delinquent development, like feeblemindedness, and a poor physical and mental make-up, might, possibly, be hereditary, but delinquency in itself is a social, or antisocial, growth.

The studies of Burt and Williams reveal positive association between poor home conditions and delinquency, although it is not known to what extent. Similar home conditions may be in existence in the case of a group of unselected boys who are properly adjusted socially; Fernald [16] found that 87 per cent of delinquent girls came from broken homes. The methods of studying home conditions have been very unsatisfactory, and results are hardly comparable. Williams has recently devised a scale for the grading of homes and of neighborhoods [17] which makes it possible to get comparable data on the home and neighborhood conditions of widely different groups.

3. *Some Specific Test Methods:*

Apart from these general survey methods of investigation into the contributing causes of delinquency, mention must be made of other attempts at analysis of more specific phases of character. Thus Webb,[18] in his study of character and intelligence, attempted an analysis of character by means of tests and trait ratings.

[16] Fernald, Grace M. Delinquent Girls. *Psychological Bulletin,* Vol. XII, No. 9, 1915.

[17] Williams, J. Harold. *A Guide to the Grading of Homes; A Guide to the Grading of Neighborhoods.* Whittier State School Bul., Nos. 7 and 8.

[18] Webb, Edward. *Character and Intelligence.* Brit. Jour. Psy. Monograph Supplement No. 1, 1915.

Webb demonstrates that a " second factor," apart from intelligence, exerts a widely ramifying influence on the side of character. This factor, he states, is akin to " persistence of motives."

The questionnaire method, used so extensively by Heymans and Wiersma, has been developed by Hollingworth [19] into a method of discovering pathological states of experience with adults, and Johnson [20] has in turn developed it for use with children.

Downey [21] has developed a series of will-temperament tests with the primary object of measuring the relation between temperament and capacities like speed of movement, freedom from inertia, flexibility, speed of decision, motor impulsion, assurance, resistance, motor inhibition, care of detail, coördination of impulses, perseverance, revision. Several investigators have tried out her methods with varying degrees of success.

Attempts have been made by Pressey [22] to investigate the emotions by means of test problems. Kohs [23] has made use of different test devices—association, practical judgment, etc.—in developing an " Ethical Discrimination Test."

Another promising departure in the field of character study through a test method is that of Voelker.[24] He developed tests with a view to getting a measure of the extent to which the social attitudes of boys were being influenced by a course of training in citizenship. His tests are particularly connected with situations of truthworthiness and honesty.

In conclusion, the scale of Upton and Chassel [25] for measuring qualities of citizenship and general social adjustment may be mentioned.

[19] Hollingworth, H. L. *Vocational Psychology.* Appleton, 1917.

[20] Johnson, Buford. Emotional Instability in Children. *Ungraded,* 4, 1920.

[21] Downey, June E. The Will-Profile. *Dept. Psy. Bul., Univ. Wyo.,* 1919.

[22] Pressey, S. L. A Group Scale for Investigating the Emotions. *Jour. Abnormal Psy.,* 16, 1921.

[23] Kohs, S. C. An Ethical Discrimination Test. *Jr. Delin.,* 7, 1922.

[24] Voelker, Paul I. *The Function of Ideals and Attitudes in Social Education.* Columbia Univ. Contributions to Ed., 1921.

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4. *Considerations for Present Investigation:*

As was stated in a previous section, the investigations of delinquent development have in the main been of an historical nature. The general findings of these studies throw a great deal of light on the process of development of delinquent practices. It was the purpose of the present experiment to utilize some of the known facts of delinquent growth in the service of a test method. The following are some of these characteristics that have been noted:

a. Delinquents are not a distinct group.
b. Delinquency is a term relative to the social and moral standards of a particular age.
c. It is an outgrowth of numerous contributing factors.
d. These different factors can be recognized and examined.
e. Some of the main factors are:
    1. Physiological.
    2. Social and economic.
    3. Psychological.

In the experimental method that was developed in this study, an attempt was made to get some idea of the extent to which the individual acts with foresight and deliberation, whether or not he has some appreciation of social and moral standards, and how he appreciates his own abilities, interests, and capabilities. The method was thus the reverse of the proceedings reported earlier in this chapter. The problem thus resolved itself into the question of an analysis of the subject *as he is now,* and in the environment in which *he finds himself now.* The question was: Does the boy show signs of delinquent interest and practice? If so, can the contributory factors not be discovered in a test situation?

CHAPTER II

DEVELOPMENT OF TEST MATERIALS AND METHODS

Section I

Factors Involved in Selection and Development of Test Materials

A great many of the practices that have been developed and standardized in the field of intelligence testing and educational measurement are of service in connection with the development of character-behavior tests. In the first place, the problem situation has been the main concern in the method of approach in each of these fields of investigation. The ways in which laboratory test situations have been defined and developed may be readily adapted to the needs of an analysis of behavior tendencies. Again, many of the test forms—performance, completion, underscoring, etc.—and administration devices may be utilized. And lastly, many of the scoring and statistical methods may lend themselves to ready use in this other field.

There are, however, certain very fundamental differences to be noted between tests of achievement and ability, on the one hand, and tests of behavior and moral development, on the other, regarding: (1) The factors constituting the problem situation; (2) the attitude of the subject toward the test problem; (3) the examiner and the constitution of the test group. These are critical factors in the development of methods for behavior tests.

1. *The Factors Constituting the Problem Situation:*

In the case of achievement tests the problem is framed so as to afford opportunity for the expression of ability and proficiency. The subject is faced with the problem of demonstrating his ability to memorize material; to perform certain operations in arithmetic, writing, etc.; to comprehend relationships of objects and

statements; to discriminate between colors, forms, weights, words, etc.; to reconstruct a situation when only certain particulars are known; to know how situations ought to be met; and so on. The emphasis is in the main on the *ability* of the subject to perform certain tasks of reasoning, on whether he *knows* how he *ought* to act under certain given conditions.

The situation in human behavior, on the other hand, is one involving a *type or degree of activity or attitude,* as contrasted with a type or degree of knowledge; doing a thing, cherishing, avoiding, desiring something, as contrasted with knowing how to perform a task, knowing what is desirable, or why a particular practice should not be cherished. It is the difference between a boy's knowing all about the consequences of cheating, stealing, or destroying property; or his ability to know how to make correct change, how to play cards, how to drive an automobile, to comprehend a commission, to know the enactments of the law, in one case; and his breaking the law, failing to carry out orders, ignoring speed limits, withholding change, destroying property, stealing and cheating, in the other, in spite of what he knows about the implications of such practices.

The problem situation in the character-behavior tests—more particularly in those that concern delinquent behavior—should, therefore, approximate this second state of affairs. It should be a situation in response to which the subject would unfold his desires, preferences, interest in forms of activity, social likes and dislikes, respect or disrespect for the claims of the law and of society in general. To set up a test situation to meet such demands seems to be almost an impossible task.

However, it must be stated at once that this distinction between ability and practice, between knowing and doing, cannot be forced to the point of mutual exclusion. Such is seldom, if ever, the case in the experiences of the individual—*i.e.,* when the feebleminded and the insane are excluded from consideration. An understanding of the situation undoubtedly influences the resultant response, even if that response were contrary to, or other than, the best judgment of the individual. A knowledge of the claims of the

law; an understanding of the rules of the game; a grasp of the principles involved in calculation; the ability to reason about the merits of a case, have undoubtedly a far-reaching influence on the determination of the actions of the individual as to the type of citizen that he is; whether it might be expected of him to play fair, or even to play at all; whether he can be trusted to conduct a correct and honest business deal; and whether it could be required of him to give an unbiased and just decision. There is always this bi-polar consideration in every human act, and it is impossible to separate these to the extent of mutual exclusion without destruction of the whole.

Since, therefore, this complementary relationship between ability and behavior in the practical situations and decisions of experience (in spite of the willful subjugation of the one to the other at times) the difficulty of setting up test situations in which more particularly the behavior tendencies of the individual can be discovered becomes all the more baffling, and challenges experimentation.

2. *The Attitude of the Subject Toward the Test Problem:*

How then might the behavior tendencies more particularly be approached in a test situation? The question thus stated causes a second difference to be noted between mental tests and tests of behavior, viz., the required difference of attitude on the part of the subject. This general difference of attitude that is sought will be determined by: (a) The nature of the preliminary instructions; (b) the nature of the test form and the materials involved; (c) the possible interpretation that the subject himself may be inclined to place on the implications of his responses. The nature of the initial "report-attitude" of the subject will be greatly influenced by the frank assurance that the situation does not call upon him to "make good," to sustain a reputation, to make an effort to excel, to prove his mettle. This is what is emphasized at the outset in the case of tests of achievement, and such commissions as "We want you to do the very best you can" in no small measure influence the initial "report-attitude" of the subject. It is just this type of influence that is to be avoided in

connection with the creation of the test atmosphere of tests of behavior; and on the contrary, an unrestrained, frank, and almost naïve attitude and expression should be sought. In fact, no reference to an idea of "making good" should even be hinted at; there should be no factors of circumstance in existence that might create a feeling of suspicion or uneasiness in the mind of the subject. Any attempt to make an analysis of the behavior of a juvenile delinquent by means of a test situation during the period of the court trial bears its certain failure in its method. The same is true to a certain extent of any specially selected group, where the basis of selection is known to the individuals of the group.

The materials and the form of the test, too, are of great importance in the creation of a desirable test atmosphere. The materials, in so far as is possible, should be related to the many phases of the subject's activities and interests; and the stimulus should be one that would set off a natural line of association and response. Considerations of knowledge or ability are to be avoided, excepting in so far as information is sought concerning the attitude of the subject towards his own achievement and abilities, or statement thereof.

As for the interpretation on the part of the subject of the implications involved in his own responses, this might possibly be greatly minimized by the avoidance of any reference to what is acceptable or nonacceptable, good or bad, wrong or right; and by the avoidance of such questions as, "What's the thing for you to do?" or "What best explains?" when certain statements of ethical evaluation follow. On the contrary, a frank statement about the school, teachers, books, forms of amusement, and the like, would more likely approximate the preferences, desires, tendencies, and actions of the subject. But how is such a frank statement to be secured?

3. *The Examiner and the Constitution of the Test Group:*

The answer to the above-mentioned question involves a third difference between the test conditions for achievement and those

for behavior traits, viz., the nature of the examiner and the constitution of the group.

In the case of mental and educational tests any thoroughly trained examiner will suffice, whether he is known to the subjects or not, whether he is connected with the subjects as teacher or in some other responsible manner or not (there are occasions when a stranger might be more acceptable). In the test situation for behavior tendencies the examiner should preferably be an individual with whom the subjects are not acquainted, and who is not connected with the school or community-life of the group. Such an absence of a tie of any kind is apt to " let the lid off," especially in the case of young children. A knowledge of the fact that the examiner is in no way connected with the school, the teachers, the police organization, and the like, will in no small measure enhance a frank statement on the part of the subjects.

Another factor that would contribute to frankness of response is whether or no the subject is tested alone or with the group. Here, again, where mental testing practice would favor an individual test, *a priori* judgment concerning a character-behavior test would favor the group method. Pedagogical experimentation has shown that the influence of the group tends to lend a boldness and security in expression, which is exactly what is desired in the test situation under discussion. It is the same influence at work when a lad is bold enough to pin a tail to the policeman's coat as the gang goes down town. An individual test situation is too personal, and an honest and frank statement upon the part of the subject too embarrassing. The test in a group form removes this barrier of the personal equation.

When the constitution of the group is considered, it will be readily agreed that, because of the different social factors that enter into the childhood experience of boys and girls, their consequent behavior—especially delinquent behavior—will be partly different, and that therefore the groups are to be tested apart. The materials, too, ought to be different in part.

Whether or no the subject will " come through " when all these cautions are observed may still be an open question, just as it is

impossible to say that the subject has completely revealed any quality of his in a test situation, whether that other situation is a test of his ability to reason, or to discriminate between objects, to spell a word, or what not. There always remains the possibility for the subject to hold back deliberately, through fear of making a mistake, and the like. This possibility is in no way removed if the afore-mentioned cautions are observed, but there are grounds —actual trying out of different methods—for believing that a feigned response will seldom, if ever, be sustained throughout, especially when the test covers a wide range and great number of items. Children are, on the whole, as frank and open in their expression as the occasion demands.

The test development and the experiment reported hereafter constituted an effort to set up a test situation where the controls and considerations discussed above were observed as carefully as possible.

Section II

Procedure Adopted for Obtaining Materials and Developing Test Forms

A survey of the tests that have been developed for the purpose of character analysis, with a view more especially to the discovery of the onset and development of delinquent practices, and tests that would meet the considerations discussed in the previous section and in Chapter I, proved that few, if any, such existed. It was therefore thought best to make a bold attempt to develop some exercises that might more closely approximate an instrument for detecting differences of character tendencies, and more particularly for the development of practices that are questionable for, and injurious to, the best interests of the individual concerned. Two factors were of chief concern in this undertaking: (a) The materials that would be of significance in bringing out the delinquent interests; and (b) the form in which these materials had to be clad to constitute a natural and legitimate test situation.

(a) In order to get a clue to some of the many factors and situations that are instrumental in bringing about a critical depar-

ture toward delinquent development, a study was made of the literature on the subject, and the most significant and recurrent critical incidents, situations, and circumstances noted, that had acted as stimuli for setting off a line of action and interest, which ultimately led to delinquent practices. The literature covered included the studies of investigators like Healy, Fernald, Goddard, Kelley, Williams, Bronner, Porteus, Tredgold, Burt, and others; reported case histories; reports of the National Committee for Mental Hygiene; the case history files at Whittier State School; clinical discussions; and the reports of probation officers and juvenile court judges. The following are among the most prominent factors reported (leaving out of consideration the matter of mental deficiency). They are given here at random; no special significance should be attached to the order in which they are listed; also no one factor is exclusive of the influence of any of the others.

1. Associates—gang type, older, wealthier, hoboes, hard-boiled, indifferent, coarse.
2. Movies—and in no small measure the advertisement posters.
3. Books and papers, pictures—especially related to sex matters.
4. Home conditions and relationships—relation of parents to one another and to their children; type of supervision; doing chores; enforced religious observances; lack of congenial social life.
5. Economic factors—desire for having own money to spend; working without tangible remuneration; ease of borrowing; ease of getting a job; easy use of checks; scant provision in the home; too much pocket money.
6. Wanderlust—ease of getting lifts on passing automobiles and on freight trains; lure of getting to the crowds of the city and to the country.
7. School conditions—class work poorly adjusted to ability; unsympathetic teachers; exacting discipline.

8. Amusement places—shooting gallery, circus, poolroom, bowling alley, peep shows.
9. Early responsibilities and duties—selling papers, messenger boys, office boys.
10. Contact with the demands of law and discipline—rowdyism, vagrancy, smoking, prohibition, school attendance, respect for property.
11. Sex appeal—perversions; illicit practices.
12. Athletics—lack of healthy recreation; no playgrounds; poor type of physical directors; wrong information concerning Boy Scouts and boys' clubs.
13. Physical conditions—undirected regarding habits of cleanliness; undernourishment; no medical care.
14. Emotional instability—explosive temper.

In considering the above factors it must be noted that no single factor ever seemed to operate singly as an only cause for delinquent development; many factors combined in various degrees, the one lending impetus to the other, acted as contributory influences. Broken homes, in the widest sense, was perhaps the most outstanding feature noted, and poor adjustment in the school next, with a yearning for economic independence following closely.

Another fact, important for the detection and prevention of delinquent development, became evident from the analysis of the case histories recorded, viz., that while a boy was apprehended before a court or social agency on a certain date for some or other misdemeanor, the beginning of the final undoing could be definitely traced back to a crucial experience with some of the above-mentioned factors a year or two previously. The final move was but the breaking point of a wave, swept up from many angles further back.

It is also important to note that while the age distribution of apprehended juvenile delinquents ranges all the way from five years upwards, the mode seems to fall around thirteen and fourteen.

(b) Selection of test forms: In order to approximate the test

situation described in the first section of this chapter, it was decided to select such problems as would throw light upon the following questions: (1) To what extent does the boy readily seize upon a chance to appear as having exceptional book knowledge, but falsely so? (2) To what extent will the boy seize upon an opportunity to appear as being well informed concerning a wide range of facts, and as having thoroughly mastered a variety of activities, when that is not the case? (3) What is the persistent trend in the choice of his associates? To what extent is his choice characterized by an interest in questionable and harmful determinants? (4) What is the trend of his interests in various forms of activity? To what extent are they antisocial or questionable socially? (5) What is the habitual reaction to different social and educational institutions, like the school, the home, Boy Scouts, etc.? To what extent do they reveal questionable judgment? Questionable adjustment? (6) To what extent does the boy recognize the harmful results of antisocial practices? In how far does his judgment harmonize with accepted social standards? The emphasis in all these questions is on the nature and extent of an interest in and preference for matters questionable for the healthy development of the boy, and on his habitual reaction to his own abilities and range of information.

Test I—Books Read: (For this and succeeding tests and instructions, see Chapter III, pp. 22–47.

In Test I an answer was sought to question 1 raised above, viz., To what extent does the subject give a false impression of his literary interests? The idea was taken from Franzen's experiment [1] for intellectual honesty, and was developed in conjunction with Dr. G. M. Ruch, Iowa State University, into a form suitable for boys. The subject had to mark from a list of fifty books, divided into two forms of twenty-five each, those books which he is supposed to have read, no matter how long ago. Twenty fictitious titles were included in the list, titles which are more or

[1] Franzen, Raymond. Measurement of Non-intellectual Aspects of Behavior. Proceedings of First Am. Conference of Ed. Research and Guidance, *San José State Teachers College Bul.*, 1922.

less of the same descriptive character as the rest. The particular object in doing this was to find out how many of these fictitious books would be marked by the subject, it being thought that such a misstatement on the part of the subject might be an index to his mental honesty. Franzen found that " one-third of the teachers of a typical school somewhere in the Middle West showed unmistakable signs of such mental or intellectual dishonesty."

Test II—Character Preference:

The second test was an attempt at an answer in part to questions 3, 4, and 5 (pp. 30, 31), with an emphasis on choice of associates. The idea and the method are practically the same as those of the first test. In this case sixteen character descriptions were developed into two forms of eight each. Different types of boys were selected, and they were described in a very concise and simple manner in terms of their activities and interests; these activities and interests cover a wide range of actual conditions and experiences of boyhood, and they were combined in a varied manner so as to form a graduated series of questionable or desirable influences. Any reference as to whether a character was good or bad was carefully avoided in the descriptions; a bare statement of supposed facts was all that was given. It might be stated that some of the characters thus described were approximations of types and stages reported in case histories of delinquent development. The full-fledged culprit, as he appears in court, was obviously excluded from the list, especially the sex offender.

The task for the subject here was to rank the characters in the order in which he would like to associate with them as chums or pals. It was not a hard task, nor was it foreign to the experience of the boy. He goes about the playground, the street, and the home every day lining himself up with other boys just because of the specific activities in which they are engaged, and the plans that they are developing. Whether or not the boy would be honest about his stated choice is a moot question. All that can be said at this point is that the results showed remarkable differentiation between the rankings of different subjects.

Test III—Reading Preference:

Test III was developed for the purpose of answering questions 3, 4, and 5 in part (page 32), concerning the attitude of the individual toward associates, activities, and institutions. The instrument for the presentation of the test problem again was book titles. Twenty book titles, all specially created, each title suggesting some phase of boyhood activity, questionable and otherwise, as forming the theme of the book, were presented to the subject in two comparable forms of ten each. The subject was asked to indicate the order in which he would care to read the books.

The question of whether the boy reads or not was of no concern. It was rather to the nature of the activity, clad in the form of a title, and suggestive of the development of the supposed story (such as is the case with very many actual boys' books, and especially true of movies) that the subject was sought to respond. It is a matter of common experience to find books selected on that basis. The task here was one akin to the everyday experiences of the subject, and it is doubtful whether its implications would be guessed at all by very many in a group. When judged from the results, the number that definitely detected the implications was very small indeed.

Test IV—Activity Preference:

This test was developed also to throw light on questions 3, 4, and 5 (page 33)—more particularly question 4, the matter of the boy's activity preferences. From the literature of delinquent development, more particularly from the Whittier social case histories, incidents were chosen which had actually been points of departure in the delinquent development of many boys, and were grouped in sets of three; two of the three activities were questionable for the social development of a boy, if participated in; one was acceptable. The sets or groups were built up around such activities as forms of amusement, methods of securing money, spending leisure time, getting about, sport, and self-improvement. Any type of activity that is related to adult life and in which almost every child has a passing interest, like being

a fireman, an engineer, etc., was avoided. Particular care was taken not to have the acceptable activity of a prudish type, but rather genuinely wholesome and virile. The task for the subject was to check, in each group of three, the *one* thing he preferred to do. Whether or not the subject was spontaneously frank can only be judged from the character of the results.

Test V—Controlled Association:

The purpose of this test was to get additional information through a method of controlled response concerning questions 3, 4, and 5, more particularly to question 5 (pp. 34–36), viz., the habitual reactions of the individual to social and educational institutions. The expression "controlled association" is here used in the sense that the response is so restricted that only one term may be deemed socially acceptable. The method was that of taking various institutions that enter into the life of the subject, like the teacher, the scout movement, policemen, smoking, etc.; then four statements, such as are frequently made about these matters, were developed in connection with each—three being questionable and one acceptable—and the subject was asked to mark the *one* that came nearest telling how he felt about the institution in point.

It might be explained that the institutions chosen were taken from the case histories recorded, where the experience of boys with, and their attitude towards, these institutions proved to be critical factors in their delinquent development. The language in which the affective statements were couched was made to approximate the common phraseology of the boy among his associates, the endeavor here being more particularly to tap the *affective* rather than the rational processes of the subject. Here, again, any doubt as to the honesty and frankness of the response can be cleared only by reference to the results.

Test VI—Offense Rating:

By means of this test an answer was sought to question 6 (pp. 37, 38), viz., the extent to which the harmful results of antisocial practices are recognized. The test was suggested by and

developed in conjunction with Dr. G. M. Ruch. The idea was one tried out by Fernald [2] and by Jacobsohn-Lask [3]; both of them had individuals rank offenses in the order of their seriousness. Fernald had a series of acts ranging from what were acceptable and praiseworthy to what were harmful and criminal. The subject had to rank these in the order of their praise- and blameworthiness. Lask had a series of delinquent acts which the subject had to rank in the order of their seriousness. Both investigators compared the ranking so derived with a standard ranking which was the combined rankings of competent judges. It was decided to follow the procedure of Lask, and, in order to bring the offense within the limits of the boys' experience and knowledge of such matters, the offenses were selected from the items of Clark's Rating Scale of Offenses, where the offenses are those of actual boys now committed to a reform school. Clark had some competent judges rate these offenses according to their seriousness, and then constructed a scale that recorded the offenses in the order of their seriousness, the differentiating steps of seriousness being approximately equal according to the amount of agreement between the judges.

Two forms of ten items each, the items in the two forms being comparable as regards seriousness, were then selected, and the subject was asked to rank these in the order of their seriousness according to his judgment.

Test VII—Overstatement:

The purpose of this test was to seek an answer to question 2 (pp. 39–47), viz., To what extent does the boy misinterpret his own range of knowledge and capabilities? Voelker [4] successfully developed the idea of checking such overstatement or misinterpretation in a test situation. He had the subject rate himself on ten questions regarding his own ability and knowledge, and then had

[2] Fernald, Guy G. The Defective Delinquent Class Differentiation Test. *Amer. Jour. of Ins.*, 68, 1912.

[3] Jacobsohn-Lask, L. *Uber die Fernaldsche Methode zur Prüfung des sittlichen Fuhlens und über ihre weitere Ausgehaltung.* Leipzig, 1920.

[4] Voelker, P. F. *The Function of Ideals and Attitudes in Social Education.* Columbia Univ. Contributions to Ed., 1921.

him vindicate his knowledge in a subsequent information test. Cady tried out Voelker's method and found it very significant in diagnosing cases of incorrigibility. It was thought that ten items were too few, and that a wider range of experience and knowledge ought to be covered; consequently the present forms, A and B, were developed (in conjunction with Dr. G. M. Ruch) so as to have forty items in each form. The items were arranged in the order in which boys would be commonly familiar with the facts of knowledge and experience required or involved.

The selection and the order of the items were determined in the following manner: About 120 items of various forms of information and degrees of difficulty were submitted to about 300 unselected grammar grade pupils (grades 4–8) in San José. The percentage of cases that overstated or understated themselves on each item was calculated. All items on which from 0 to 15 per cent of the cases overstated or understated themselves were discarded. The remaining eighty items were then divided into two comparable forms in which the items were arranged in the order of percentage of cases originally over- or under-stating themselves on each item, *i.e.*, from 15 per cent upwards. The form of the test, then, was in the nature of a questionnaire and a subsequent check. A practice exercise was added with the purpose of familiarizing the subjects with the task of evaluating their own confidence in their own knowledge and ability. The items here were extremely simple in order to secure willing and ready coöperation from the subjects in the subsequent test forms.

CHAPTER III

TESTS, INSTRUCTIONS, AND METHODS OF SCORING DEVELOPED

While the term " test " has been used very frequently in the discussion of the previous chapters, the expression was never actually used in the experiment that formed the basis of this study. The reason why this was done was because it was felt that the term " test " had acquired a connotation through usage with tests of ability that is almost synonymous with " making a supreme effort to excel " or " to do the very best you can." As stated in the previous chapter, such an attitude would have defeated the aims for which the blanks were developed. As a matter of fact, in the sense of current usage, the term " test " should not be applied at all to the blanks developed for this study. The term was introduced in the previous chapters, and will be used throughout the discussion, instead of " exercise " or " blank " simply so as not to add another to the terms already used in tests, scales, measures, etc. It must therefore be remembered that the term " test " is here used in the sense of an exercise in which the subject merely maps out his interests and preferences. When the subject was informed through the instructions that he was not going to take a " test," it was meant that he was not going to face a situation in which he would have to prove his ability, as he has had to do occasionally in the past when taking tests. There is no doubt but that the assurance was interpreted in just that manner.

The purpose of this chapter is to report the instructions for giving the tests, the test blanks and the method of scoring developed. The reports of the instructions are in verbatim form, and are grouped together with the tests which follow.

Section I

Test Instructions

Order of Giving Tests:

1. Test I—Books Read, Form A.
2. Test I—Books Read, Form B.
3. Test II—Character Preference, Form A.
4. Test III—Reading Preference, Form A.
5. Test II—Character Preference, Form B.
6. Test III—Reading Preference, Form B.
7. Test IV—Activity Preference.
8. Test V—Controlled Association.
9. Test VI—Offense Rating, Form A.
10. Test VI—Offense Rating, Form B.
11. Test VII—Overstatement, Part I, Forms A and B.
12. Test VII—Overstatement, Part II, Forms A and B.

The tests were arranged thus so as to avoid as much as possible any effect carrying over from the one test to the other, and to postpone to the last any intimation regarding the check that comes in Part II of the Overstatement Test. The second forms of Tests I, II, III, and VI should preferably have been given on different days, but for the fact that the subjects would undoubtedly discuss with one another the contents, and perhaps even the implications, of the tests, a matter which would very seriously affect the consequent results. Because of the very nature of Test VII the second form must be given at one and the same sitting with the first.

General Instructions:

"I am going to give each of you blanks like these, on which I am going to ask you to mark some of your preferences and desires, what you know and think about some matters. These blanks are not tests; you are free to state your preferences; and you have as much time as you may reasonably require. Do not

touch these blanks until I tell you what to do." (Care must be taken that the blanks are never referred to as tests.)

Test I—Forms A and B (Exercises 1 and 2 on the blanks).

After name, etc., are filled in. "Read the directions here (pointing): 'We want to see ——,' etc." (E. reads entire directions aloud, and encourages the group to go about their task as brightly as possible. This is done merely to avoid unnecessary delay. After all are through those who got 20 or more hold up hands; then 15 or more, 10 or more. No comments are to be made. Procedure for Form B is exactly the same.)

Test II—Form A (Exercise 3 on the blanks).

Have pupils place their pencils on the desk. This must be followed out very strictly so as to insure the reading of the material on the blank they are about to work on.

"Look at Exercise 3. On this page you will find eight paragraphs. Each paragraph tells us something about a certain boy, what he is like, what he wants to do. Read through all of the paragraphs, and *find the boy that you would like to have for a chum, for a pal, the boy that you would like to go about with.* Remember, one boy only." (Do not let the pupils handle their pencils; be sure that they are reading, and let them wait until they have apparently all got their choice fixed.)

"Now put a figure 1 on the dotted line on the right of the boy you have chosen." (Let them put their pencils down again.) "Next find *the boy you like second best,* and mark that 2." (Pause a while for them to complete the commission.) "Then the *one you like only third best,* mark that 3; and so on up to 8, which will be the one that you do not like at all. Be sure that you do not leave a paragraph out, and do not put two 4's or two 7's, etc." (E. goes about to see that pupils do not miss a paragraph or that they do not mark a tie. If he finds a case he will simply say: "Look, you have left out that one," or "You have two 4's," etc., as the case may be. An effort should be made to get the task properly done; a paper with one or two characters left out will be useless.)

Test III—Form A (Exercise 4 on the blanks).

Have pupils place their pencils on the desk. "Look at Exercise 4. Here is a list of books. I want you to go through the list carefully and find the *one book that you would most like to read or have.*"

When all have made their choice: "Now put a figure 1 on the dotted line before the book you have chosen. Be sure it is only one book." (Pencils down again.)

"Now *find the book you only like second best and mark it 2.*" (Pencils down again.) "Then find the one you like only third best and mark it 3; then 4, 5, and so on until you come to 10, which you do not care to read or to have at all. Do not miss a book, and be sure not to have two 4's, two 7's, etc." (Directions may be repeated if necessary. E. should walk around quietly and watch for omissions and tie ratings.)

Test II—Form B (Exercise 5 on blanks).

Have pupils place their pencils on the desk. "Look at Exercise 5. Here again we find eight paragraphs. Each paragraph ——," etc. (Same as for Test II, Form A, Ex. 3.)

Test III—Form B (Exercise 6 on blanks).

Have pupils place their pencils on the desk. "Look at Exercise 6. Here we have another list of books. I want you to go through this list just as you did the previous list and find," etc. (same as for Test III, Form A, Ex. 4).

Test IV—Activity Preference (Exercise 7 on the blanks).

Do not turn to this exercise until preliminary explanation has been made.

"If you could choose to do one of the following, which would you choose? Remember you have only one choice:

Ride a horse? Sail a boat? Drive a car? Hands up—those who say "Sail a boat." (Do the same for the other two.) "Do you notice that you do not all like to do the same thing? Now look at Exercise 7. On this page you will find three things that

you can do under A, three things under B, and so on. I want you to *put a cross in front of the one thing in each group that you would like to do,* if you had only those choices. Don't forget you have only one choice from each group, and do not leave out a group." (E. should walk around quietly and watch for omissions.)

Test V—Controlled Association (Exercise 8 on the blanks).

"Turn to Exercise 8. Look at the word *Chums* at the top of the page. After the word *chums* there are four statements that tell how one might feel about *chums. Find the one statement that comes nearest telling how you feel about chums,* and put a cross on the dotted line after it."

"Next read the four statements about *playgrounds,* and put a cross after the one statement that comes nearest telling how you feel about playgrounds."

"Do the same for each of the others, *Boy Scouts, playing hookey,* etc. There are two pages of these; go right on to the second page when you are through with the first." (E. should walk around quietly and watch for omissions.)

Test VI—Offense Rating, Form A (Exercise 9 on the blanks).

Have pupils place their pencils on the desk.

"Turn to Exercise 9. Read the directions at the top of the page." (E. reads the entire directions aloud, and then gives the following directions):

"Will you read through the ten paragraphs given below, and *find out the offense, the wrong act, that is not quite as bad as what the others are.*" "Be sure and get one only." (After they have all fixed their choice): "Now mark the one that you have found with a figure 1 on the dotted line after it." (Pencils down again.)

"Next find the one that is just a little bit worse than this one, and mark it 2." (Pencils down again.)

"Now find the one that is just worse than that, and mark it 3; and so on 4, 5, etc., until you come to 10, which will be the worst one. Be careful not to have two 5's, two 8's, etc., and do not omit any." (E. should walk around quietly and watch for omissions or that they do not mark a tie.)

Test VI—Offense Rating, Form B (Exercise 10 on the blanks).

Have pupils place their pencils on the desk.

"Look at Exercise 10. Here again we find 10 short accounts of ——," etc. (Same as for Test VI, Form A, Ex. 9.)

Test VII—Overstatement, Part I, Forms A and B (Exercise 11 on blanks).

"Turn to Exercise 11, Practice Exercise. Read the directions." (E. then reads through each sample question, and asks the pupils to mark themselves 2, 1, or 0, as explained in the directions. When they have added up their scores he makes them hold up their hands as they have more than 15 points, 10 points, and 5 points.)

"Now turn to Exercise 11. Here you have some more questions just like you had before. I want you to mark yourself again just as before: 2 means you know it very well, 1 means that you know something about it, and 0 that you know nothing about it. We want to see what your score will be like." (E. reads each question and has pupils put down 2, 1, or 0. When Form A is completed, Form B is done the same way.)

Test VII—Overstatement, Part II, Forms A and B (Exercise 12 on blanks).

"Turn to Exercise 12. Read the directions. Look at the samples: 'The number of days in a week is 5, 6, 7, 8.' The right answer is 7, so 7 has a line under it. Look at the second sample: 'New York is in England France Spain United States.' The right answer is United States, so United States has a line under it. Below are a number of sentences of the same kind. You are to read each sentence and draw a line under the *one word* that makes the sentence true. Go right on to Form B when you are through with Form A."

(See that pupils do not stop at end of first page. Allow enough time for all, or practically all, to finish. Exceptionally slow pupils may be urged to go faster.)

Section II

Tests Developed

In this section examples are given of the tests developed. In the experiment reported in the next chapter, the word test did not appear on the blanks nor in any statement or the instructions. The tests were given in the order stated in Section I. They are reported here in a different order merely to have the separate forms of the test together.

EXERCISE 1

Number F Form A

Name..... Age..... Grade.....

Directions:

We want to see who has read the most books. You are to mark a cross on the dotted line in front of every book you have ever read, no matter how long ago you read it. After you have finished marking the crosses, count up the number of crosses you have marked. This number will be your score. We want to see who will have the best score. Afterwards we will have you stand up and tell your score. A PERFECT SCORE IS 25. Look at the sample.

Sample:

1..X..Anderson's Fairy Tales

1.....Robinson Crusoe
2.....Little Men
3.....Uncle Remus Stories
4.....The Underground Patrol
5.....White Fang
6.....Tale of Two Cities
7.....Alaskan Gold Stories
8.....Kidnapped
9.....The Boy Thief
10.....The Pirate's Revenge
11.....Lady of the Lake
12.....Penrod
13.....Kit Carson's Last Ride
14.....Boys of '76
15.....The Guns of Bull Run
16.....By Pike and Dyke
17.....Tom Wilson and His School

(Go to top of next column.)

18.....The Prize Fighter's Story
19.....The Half Back
20.....The Captain's Daughter's Secret
21.....Sea-side Adventures
22.....Hans Brinker
23.....Scouting in Strange Lands
24.....Five Little Peppers
25.....By England's Aid

NOW COUNT UP YOUR SCORE AND PUT THE NUMBER YOU HAVE READ IN THE SPACE HERE. Remember, a PERFECT SCORE is 25.

MY SCORE IS.....

EXERCISE 2

Number F Form B

Name..... Age..... Grade.....

Directions:

We want to see who has read the most books. You are to mark a cross on the dotted line in front of every book you have ever read, no matter how long ago you read it. After you have finished marking the crosses, count up the number of crosses you have marked. This number will be your score. We want to see who will have the best score. Afterwards we will have you stand up and tell your score. A PERFECT SCORE IS 25. Look at the sample.

Sample:

1..X..Anderson's Fairy Tales

Begin here:

1.....Treasure Island
2.....Black Beauty
3.....The Flagman at Signal Rock
4.....Rip Van Winkle
5.....The Revolt at Bunker Hill
6.....Blind Tom's Adventures
7.....Gulliver's Travels
8.....Bob, Son of Battle
9.....The Crimson Sweater
10.....The Death of Marco Polo
11.....With Lee in Virginia
12.....Hitting the Line
13.....Don Strong of the Wolf Patrol
14.....The Mysterious Minstrels
15.....Ali Baba and the Forty Thieves

(Go to top of next column.)

16.....Scouts of the Valley
17.....Lone Star
18.....Huckleberry Finn
19.....William Chesterfield
20.....True to His School
21.....Call of the Wild
22.....Campaigning in Argentina
23.....Tom Sawyer
24.....Sunk Without a Trace
25.....The Friday Murders

NOW COUNT UP YOUR SCORE AND PUT THE NUMBER YOU HAVE READ IN THE SPACE HERE. Remember, a PERFECT SCORE is 25.

MY SCORE IS.....

EXERCISE 3

Number C Form A

Name..... Age..... Grade.....

James likes to have an easy time. His parents are not poor, he therefore thinks that it is not right that he should help around the house. He does not care much about sport, but likes to drive about in his father's car. .....

Brick is fifteen years old and is a real dare-devil. He does not care much for school-work, and wants to get out. He often goes off with the circus, and gets round by picking up rides. He thinks he will get right away now, if he can only find a chum to go with him. .....

Dick joined the Boy Scouts as soon as he was old enough. He did not like it at first; the drill and the rules were hard. Now he is a troop leader and is planning a camp in the mountains next summer. .....

Ray Stevens is at school now, but he is anxious to get out. He wants to become a taxi-driver. Ray says that taxi-drivers have an easy time; they need not work so hard, and they go about a great deal. .....

Ted is a poor boy; and, although he is at school, he must help provide for the family. Ted studies hard and also plays on the team; he wants to become a doctor. .....

Bill Evans is fourteen, and is the leader of his gang. He always manages to get his men home safely after they had a good time around the pool-room. Just last week they saw Tom Mix at the movies without paying. .....

John was a member of the Fourth Street gang up until last week. He was with Red and Tim when they got away safely with some fruit, smokes, and bicycles. They were planning a big haul, when John said he was not going to do that sort of thing any longer. He has joined the Boy Scouts now. .....

Joe Wilson is a friend of Tom Brown and Al Davis. They do not care much to be with the crowd. They like to get away alone where they can tell each other all kinds of stories, and where they can read cheap magazines. They do not care much about sports. .....

EXERCISE 5

Number C Form B

Name..... Age..... Grade.....

Douglas has studied a great deal about birds and animals. Just now he is making a collection of the pictures of the birds and wild animals of America and of other countries. He is also collecting stamps of different countries. .....

Ken Rogers—The boys round town think that Ken is a prize-fighter. He made short work of Billy Wilson and Harry Martin the other day when they were only joking with him. The little boys are all afraid of him. .....

Tom is very fond of girls. He is often with Jane and Lizzie, because they like boys. He says he does not like Mabel and Clara, because they always talk to him about their studies. .....

David Allen has just been made captain of his team. It was hard work for him to gain the honor. David also studies hard, and he is fond of reading. He sometimes writes stories for magazines. .....

Nobby Clark has fun at the expense of other people. He does not mind getting into trouble. He vexes the girls and now and then even fools his teacher. He thinks it adds to his smartness. .....

Henry loves building such things as airplanes and motor cars. He has to study hard to get to know all the parts. He is working on a wireless set now. .....

Andy is a very happy-go-lucky sort. He loves taking great chances. He would go off with somebody else's bicycle, even with the machine of a stranger. He often gets by with a clever excuse; sometimes he is not even found out. .....

Victor can play the piano well, and spends hours alone at the piano. He does not go much with boys who play basketball and football. He likes music and reading, and when he goes out it is always with one or two special boys. .....

EXERCISE 4

Number T Form A

Name..... Age..... Grade.....

Sea-side Adventures .....
The Cowpuncher's Revenge .....
The Scout That Saved His Camp .....
Breaking Through Prison Walls .....
Working and Fighting His Way to the Top .....
Pool-Room Stories .....
Bob Jones, His Gang and the Cops .....
The Boy Discoverer .....
The Hookie-Players, The Adventures of Gus and Ned .....
On the Trail of the Traitor .....

Number T Form B

EXERCISE 6

Name..... Age..... Grade.....

A Daring Rescue .....
Roy Black The Master Thief .....
Captains of Great Teams .....
Hobo Stories .....
Running Away With the Circus .....
The Adventures of Boys Who Became Great Men .....
Summer Camp Adventures .....
With the Gang in the Back Streets .....
The Boy Inventor .....
The Escape Through the Woods .....

EXERCISE 7

Number E

Name..... Age..... Grade.....

A.....Go camping with Boy Scouts.
.....Go around seeing the country getting lifts as you go.
.....Quit school and go along with the circus.

B.....Match pennies and win.
.....Have a paper route.
.....Win money at a shooting gallery.

C.....See moving pictures of burglars and how they escape.
.....See moving pictures of Jackie Coogan.
.....See moving pictures of lively parties and dancing.

D.....Go around with older boys.
.....Go around alone.
.....Go around with the family.

E.....See Charlie Chaplin on the movies.
.....Light fire-crackers in the class-room.
.....Fool round town in the evening.

F.....Go to work now as a messenger-boy.
.....Be a pin-setter in a bowling alley.
.....Go on with your lessons at school.

G.....Go for a joy-ride.
.....See a good show.
.....Shoot craps and win.

H.....Learn some trade.
.....Work in a shoe-shine parlor.
.....Show seats in the movies.

I.....Borrow a bicycle from some one you don't know when you want one.
.....Buy one and have it charged.
.....First get the money and then buy one.

J.....Read about burglars and hold-ups in the paper.
.....Read the baseball and football news.
.....Read about the boot-leggers and the police.

K.....Be a good pool player.
.....Be the leader of your gang.
.....Play on a team.

L.....Go round to the penny peep shows with your gang.
.....Look through the museum with some boys.
.....Get together in a pool room.

EXERCISE 8

Number D

Name..... Age..... Grade.....

Chums:	It is hard to go without them.....
	You cannot always trust them.....
	They sometimes squeal on you.....
	It is best to have them in your gang.....
Play-grounds:	There are always fellows watching you...
	They make you play games you don't like..
	There is no chance to do what you want to.....
	You can have a good time there.....
Boy Scouts:	They have too many rules.....
	They have to drill too hard; it is not much fun.....
	They are regular fellows and have lots of fun.....
	They are like sissies.....
Playing hookey:	It is a slick way of getting away from school.....
	Nobody knows where you are.....
	It gets you into trouble.....
	It is no harm.....
Boys' clubs:	You don't have much fun there.....
	You meet fine fellows there.....
	I would rather be with the gang.....
	They have too many rules.....
Teachers:	They work hard.....
	They know they can punish you.....
	They are not fair to you.....
	They are kind of cranky.....
Bumming rides:	You can get round to see the country.....
	It is fun to do it.....
	It makes you husky.....
	It is a poor way to get round.....
Passing checks:	To use them you must have money in the bank.....
	You can give them when you have no money.....
	It is an easy way of getting money on somebody else's name.....
	Anybody will take them for money.....

Doing chores round the house:	You never get any money for it..... ____
	It helps the family..... ____
	Other boys don't have to do it..... ____
	I don't like to do it..... ____
Saving money:	You must have lots before you can save.. ____
	It looks kind of stingy..... ____
	It will help a fellow later..... ____
	It is not worth the bother..... ____
Judge:	He likes to punish people..... ____
	He does not keep the law himself..... ____
	He does not give you a square deal..... ____
	He does what is right..... ____
Having a scrap:	It is good fun..... ____
	It is not the best way of settling things... ____
	You must take care not to pick on a big fellow..... ____
	It shows you are not afraid..... ____
Punishment:	It does not do much good..... ____
	It is a mean way of treating a fellow..... ____
	It makes you think about what you have done..... ____
	It is usually somebody else's fault..... ____
Policemen:	They have it in for the kids..... ____
	They are glad to help you out..... ____
	It is fun to fool them..... ____
	They are just big bluffs..... ____
Joy-rides:	You must just wait along the road..... ____
	You can go in somebody else's car..... ____
	Step on the gas and go as fast as you can.. ____
	Rather go with your family..... ____
Hoboes:	They are kind of friendly fellows..... ____
	They don't have to work..... ____
	They are lazy and dirty..... ____
	They have a pretty good time..... ____
Having a paper route:	It gives you a chance to get away from home..... ____
	You can earn some money..... ____
	You have a chance to get round town alone..... ____
	You don't have to be so much with your lessons..... ____

Bluffing:	You can put it over easily..... It is a good way of getting out of trouble.. It shows you are not afraid..... It really does not pay.....
Smoking:	Puts the pep into you..... Makes you look kind of manly..... Is not good for one's health..... All the boys do it when they get out.....
Borrowing a bicycle:	Your friends might not want to give it.... You need not return it soon..... If you break it your friends won't mind... You don't have to spend your own money..
Speed cops:	They are too hard on you..... You can get away from them if you are slick..... They are always laying for you..... They make driving safer.....
Captain of the team:	He is nothing but a big rough-neck..... He is a regular fellow..... He makes his men do all the work..... He is a cheap sport.....
School rules:	They are no use..... They are not fair..... It is nothing much if you can break them.. They are to give everyone a square deal...
Crap shooting:	There is nothing in it; it is all luck..... I like matching pennies better..... You can win if you go on long enough.... It is lots of fun.....

EXERCISE 9

Number R Form A

Name..... Age..... Grade.....

Directions:

Below are ten short accounts of wrong acts actually committed by boys now in certain reform schools. They were between the ages of 8 and 16.

Will you go through the list and rate each offense according to its seriousness for the one who did it and for other people. Mark the offense that is least serious 1, the next more serious 2, and finally the most serious 10. Every rank from 1 to 10 must be used and no tie ranks are permitted.

Begin here: Rank

(a) John went around with hoboes—slept out in caves, tents and boxes. .....

(b) Sam set fire to the public school which he attended in Los Angeles. .....

(c) When Bill's father started to take him to a reform school because of his being bad, he asked to return to the house to say good-bye to his mother. There he took a 22-rifle and shot his father, killing him instantly. .....

(d) Bob ran away from home and got a job, getting his room and board with another family. .....

(e) Dick signed somebody else's name to a check and got hold of $10. .....

(f) Ted played hookey to go to a circus. .....

(g) Jack, together with another boy, was accused of murder. They had been drinking, were given more liquor by two grown men, and in a fight which followed one of the men was killed. .....

(h) Bert stole scrap iron from railway cars on a siding and sold it to a junk man. .....

(i) Ray was sent to a reform school because he struck his teacher. He was accused of drawing a knife on a boy when that boy claimed a bicycle that Ray had stolen from him. He was arrested for carrying a blackjack and a knife. .....

(j) Joe entered the house of the people next door and took $2.50. .....

EXERCISE 10

Number R Form B

Name..... Age..... Grade.....

Directions:

Below are ten short accounts of wrong acts actually committed by boys now in certain reform schools. They were between the ages of 8 and 16.

Will you go through the list and rate each offense according to its seriousness for the one who did it and for other people. Mark the offense that is least serious 1, the next more serious 2, and finally the most serious 10. Every rank from 1 to 10 must be used and no tie ranks are permitted.

Begin here: Rank

(a) Ralph gave several bad checks in payment for gasoline to run his machine. .....

(b) Pat ran away from home and went to work with a circus. .....

(c) Tom, together with two other boys, had planned to commit robbery. All three had been drinking. Tom fired a shot with a revolver to halt and then rob a man who was driving a machine. He accidentally hit and killed the man. .....

(d) Roy broke into a candy store and took some candy. .....

(e) Jim made two or three threats of attack upon people. On one occasion he drew a knife. .....

(f) George played hookey on Fridays only, the days on which he was required to memorize poetry. .....

(g) Harry, together with another boy, murdered an old lady for whom they were working. They threw the body into a shallow well. .....

(h) Paul traveled around in the middle and far west while bumming his way most of the time. When he was from 13 to 15 years old he went twice from the middle west to Los Angeles. .....

(i) Henry entered a house and took a gold watch which he sold for twenty-five cents. .....

(j) Frank set fire to seven buildings with no other purpose than to get amusement. The loss was between $5,000 and $10,000. .....

PRACTICE FORM

Number O Exercise

Name..... Age..... Grade.....

READ THESE DIRECTIONS CAREFULLY

Directions:

How many of the 10 things mentioned below can you do? We want you to mark yourself on each one in this way:

I can do it very well..... 2 points:
I can do it fairly well..... 1 point:
I know nothing about it..... 0

Now go through the list and give yourself a grade of 2 points on each one that you can do very well; give yourself 1 point on each one that you can do fairly well; and give yourself 0 on each one that you know nothing about at all.

A PERFECT SCORE IS 20 POINTS. WE WANT TO SEE HOW MANY OF YOU CAN GET A PERFECT SCORE. After you finish we will have you stand up and tell your score.

Begin here: Score

1. Can you swim? ..... points
2. Can you skate on roller skates? ..... points
3. Can you drive a car? ..... points
4. Can you ride on horseback? ..... points
5. Can you row a boat? ..... points
6. Can you operate a typewriter? ..... points
7. Can you milk a cow? ..... points
8. Can you harness a horse? ..... points
9. Can you take care of an incubator? ..... points
10. Can you saw a board squarely across? ..... points

Now add up your score. TOTAL SCORE: ..... points

A PERFECT SCORE IS 20 POINTS.

EXERCISE 11

Number O Form A: Part I, Page 1

Name..... Age..... Grade.....

Directions:

Here are some more questions like the ones you just had. Mark yourself this way:

I know it very well..... 2 points:
I know something about it..... 1 point:
I know nothing at all about it..... 0

A PERFECT SCORE IS 80 POINTS. WE WANT TO SEE HOW MANY OF YOU CAN GET A PERFECT SCORE. After you finish we will let you stand up and tell your score.

Begin here:	Points
1. Do you know who discovered America?	.....
2. Do you know who saved the life of Captain John Smith?	.....
3. Do you know much about the Boy Scouts?	.....
4. Do you know where the pyramids are?	.....
5. Do you know how to play checkers?	.....
6. Do you know when to use "shall" and when to use "will"?	.....
7. Do you know how many pints there are in a gallon?	.....
8. Do you know the different ways of catching fish?	.....
9. Do you know how to play "Five Hundred"?	.....
10. Do you know who wrote "Huckleberry Finn"?	.....
11. Do you know how to play baseball?	.....
12. Do you know who wrote the Declaration of Independence?	.....
13. Do you know what the flywheel of an engine is for?	.....
14. Do you know who was the President during the Civil War?	.....
15. Do you know the difference between nouns, adjectives, pronouns, and verbs?	.....
16. Do you know which month has the longest night?	.....
17. Do you know which oceans touch Africa, America, and Australia?	.....
18. Do you know how to play chess?	.....
19. Do you know how to find the North Star at night?	.....
20. Do you know who was the prophet who spent the night in the lion's den?	.....

TURN OVER TO THE NEXT PAGE.

EXERCISE 11 (Continued)

Number O Form A: Part I, Page 2

Name..... Age..... Grade.....

	Points
21. Do you know where the gasoline and air are mixed in an auto?	.....
22. Do you know the difference between a whale and a fish?	.....
23. Do you know the wireless call that ships at sea use when they are in danger in a storm?	.....
24. Do you know where the Victoria Falls are?	.....
25. Do you know which heavenly body is nearest the earth?	.....
26. Do you know what is the record for the running broad jump?	.....
27. Do you know the difference between "priceless" and "worthless"?	.....
28. Do you know when the "Dark Ages" were?	.....
29. Do you know the Roman numbers up to 100 (like IV, VII, etc.)?	.....
30. Do you know how to find the square root of decimals?	.....
31. Do you know what period of history was called the "Middle Ages"?	.....
32. Do you know what causes the tides?	.....
33. Do you know how to multiply decimals?	.....
34. Do you know who wrote "Peter Pan"?	.....
35. Do you know in which religion the caste system is found?	.....
36. Do you know in what century English Literature reached its height?	.....
37. Do you know the difference between the Parthenon and the Pantheon?	.....
38. Do you know what a sarcophagus is?	.....
39. Do you know a material used for wireless detectors?	.....
40. Do you know how many degrees there are on a Centigrade thermometer?	.....
NOW ADD UP YOUR SCORE.	
A PERFECT SCORE IS 80 POINTS. My Score is:	.....

EXERCISE 11 (Continued)

Number O Form B: Part I, Page 1

Name..... Age..... Grade.....

Begin here: Points

1. Do you know where silk comes from? .....
2. Do you know in which month Thanksgiving comes? .....
3. Do you know who discovered the North Pole? .....
4. Do you know how long it takes the earth to turn once on its axis? .....
5. Do you know where air-brakes are used? .....
6. Do you know what instrument the sailors use to tell their directions at sea? .....
7. Do you know how often leap year comes? .....
8. Do you know how to read music from notes? .....
9. Do you know who was the first white man to see the Pacific Ocean? .....
10. Do you know where Calcutta is? .....
11. Do you know who wrote "Hamlet"? .....
12. Do you know how the parts of a bicycle work? .....
13. Do you know how the different keys are indicated in music? .....
14. Do you know who wrote "Oliver Twist"? .....
15. Do you know in which month the longest day comes? .....
16. Do you know who invented the telephone? .....
17. Do you know the difference between "noted" and "notorious"? .....
18. Do you know much about birds and their nests? .....
19. Do you know what the use of a cylinder in a motorcycle is? .....
20. Do you know what causes an eclipse of the sun? .....

TURN OVER TO THE NEXT PAGE.

EXERCISE 11 (Continued)

Number O Form B: Part I, Page 2

Name..... Age..... Grade.....

	Points
21. Do you know who wrote "Robinson Crusoe"?	.....
22. Do you know how to play croquet?	.....
23. Do you know the signals a motorist uses when he wants to turn?	.....
24. Do you know who first made a success of the flying machine?	.....
25. Do you know how to read the International Morse Code?	.....
26. Do you know how to sail a sailing boat?	.....
27. Do you know in what time the fastest runner has run 100 yards?	.....
28. Do you know how to play billiards?	.....
29. Do you know how to play tennis?	.....
30. Do you know what the receiving wires of a wireless are called?	.....
31. Do you know how they set up the type for printing the daily papers?	.....
32. Do you know the stages through which a butterfly passes in its development?	.....
33. Do you know the names of the first five books of the Old Testament?	.....
34. Do you know what mosaics are?	.....
35. Do you know where Buddhism had its origin?	.....
36. Do you know for what Michelangelo is noted?	.....
37. Do you know what the Louvre is?	.....
38. Do you know what the largest of the pyramids is called?	.....
39. Do you know what is mixed with water to make acetylene gas?	.....
40. Do you know how water enters the roots of plants?	.....

NOW ADD UP YOUR SCORE.

A PERFECT SCORE IS 80 POINTS. My Score is: .....

EXERCISE 12

Number O Form A: Part II, Page 1

Name..... Age..... Grade.....

Directions:

Draw a line under the right answer to each of the questions below as shown in the samples.

Sample 1. The number of days in a week is 5 6 7 8
Sample 2. New York is in England France Spain United States

Begin here:

1. America was discovered by Drake Columbus Balboa Cook 1
2. The Indian girl who saved Captain John Smith was Pocahontas Uncas Hiawatha Minnehaha 2
3. A Boy Scout must not eat candy ride horseback chew gum smoke cigarettes 3
4. The pyramids are in Arabia Palestine India Egypt 4
5. The king-row is used in checkers cards crokinole dominoes croquet 5
6. When a person is very certain he must say "I shall" "I will" "You will" "He will" 6
7. The number of pints in a gallon is 2 4 6 8 7
8. A fish that is caught with a fly is the cod trout carp sole 8
9. In "Five Hundred" the score for a bid of six hearts is 50 100 200 500 9
10. The usual number of innings in a baseball game is 7 9 11 12 10
11. "Huckleberry Finn" was written by Alger Dickens Henty Mark Twain 11
12. The Declaration of Independence was written by Washington Jefferson Franklin Patrick Henry 12
13. A steam engine is kept running smoothly by means of a piston fly-wheel governor cylinder 13
14. The President during the Civil War was Washington Wilson Roosevelt Lincoln 14
15. An example of a pronoun is good work you eat 15
16. The longest night comes in April June December February 16
17. The Ocean between Africa and Australia is the Pacific Arctic Indian Atlantic 17
18. The most important piece in chess is the Knight Queen King Bishop 18
19. The North Star can be found by means of the Little dipper Mars Big dipper Cassiopeia 19
20. The Prophet who spent the night in the Lions' Den was Daniel Jonah David Joel 20

TURN OVER TO THE NEXT PAGE.

EXERCISE 12 (Continued)

Number O Form A: Part II, Page 2

Name..... Age..... Grade.....

21. In an auto the gas and air are mixed in the carburetor cylinder differential radiator 21
22. A whale is not a fish because it has milk glands teeth fins a tail 22
23. The danger call of a ship is C.O.D. R.S.V.P. S.O.S. K.R.T. 23
24. Victoria Falls are in Australia Canada Africa United States 24
25. The heavenly body nearest the earth is Mars Sun Neptune Moon 25
26. The record for the running broad jump in feet is about 20 22 25 27 26
27. "Priceless" means about the same as valueless cheap valuable worthless 27
28. The "Dark Ages" began about 300 B.C. 200 A.D. 500 A.D. 1500 A.D. 28
29. The Roman number for 49 is XCIV LXXIX MCLIX XLIX 29
30. The square root of .0081 is .9 .09 .009 9 30
31. An event which took place during the Middle Ages was the Great War Reformation Fall of Rome Wars of Napoleon 31
32. Tides are caused by winds rotation of the earth attraction of the moon ocean currents 32
33. The answer for .2 times .2 is 4 .4 .04 .004 33
34. "Peter Pan" was written by Shaw Barrie Dickens Wells 34
35. A religion in which the Caste system was observed is Buddhism Confucianism Brahminism Mohammedanism 35
36. English Literature was at its height in the 16th Century 17th Century 18th Century 19th Century 36
37. The Parthenon is in Paris Rome Constantinople Athens 37
38. A material often used for wireless detectors is glass silicon mica platinum 38
39. A sarcophagus is a kind of arch church tomb tower 39
40. The number of degrees on a Centigrade thermometer is 32 100 180 212 40

EXERCISE 12 (Continued)

Number O Form B: Part II, Page 1

Name..... Age..... Grade.....

Samples:

1. The number of days in a week is 5 6 7 8 1
2. New York is in England France United States Spain 2

Begin here:

1. Silk comes from worms plants sheep goats 1
2. Thanksgiving comes in May June November December 2
3. The North Pole was discovered by Scott Cook Peary Amundsen 3
4. The time the earth takes to turn once on its own axis is about 24 hours 30 days 4 months 365 days 4
5. Air-brakes are used on automobiles aeroplanes balloons trains 5
6. Sailors tell their direction during storms by means of the rudder barometer telephone compass 6
7. Leap year comes once every 2 years 4 years 6 years 8 years 7
8. A dot placed after a note in music increases its value one-third one-half one-fourth one-eighth 8
9. The first white man who saw the Pacific Ocean was Balboa Drake Columbus Cooke 9
10. Calcutta is in India Egypt Siberia Mexico 10
11. "Hamlet" was written by Goldsmith Shakespeare Tennyson Burns 11
12. A racing bicycle should have a large front sprocket long chain large front wheel large hind sprocket 12
13. In the flat keys, E flat is always on the first line second line third line fourth line 13
14. "Oliver Twist" was written by Dickens Stevenson Mark Twain Dumas 14
15. The longest day comes in June April September December 15
16. The telephone was invented by Edison Bell Marconi Hammond 16
17. "Notorious" means the same as famous noted bad reputation unknown 17
18. A bird that lays speckled eggs is the robin blue-bird English sparrow pigeon 18
19. In a motorcycle the gasoline explodes in the carburetor radiator generator cylinder 19
20. An eclipse of the sun is caused by the shadow of the earth the moon Mars Jupiter 20

TURN TO NEXT PAGE.

EXERCISE 12 (Continued)

Number O Form B: Part II, Page 2

21. Robinson Crusoe was written by Alger Irving Defoe Dickens 21
22. Wickets are used in playing tennis croquet soccer hockey 22
23. When a motorist wants to turn to the right he must point his hand to the ground up to the front straight to the side 23
24. The first successful machine to fly was made by Fulton Stevenson Wright Zeppelin 24
25. In the International Morse Code one dot is A M E R 25
26. When you sail a boat against the wind you have to drift tack scull reverse 26
27. The best time for the 100 yard dash has been about 8:3 9:3 10 10:3 27
28. The number of balls needed in playing billiards is 3 4 10 15 28
29. The score in a "love-set" in tennis is 8–6 1–6 6–6 6–0 29
30. The receiving wires of a wireless are called the amplifiers detectors reflectors antennae 30
31. The machine used for setting up the type for the daily paper is called a printing-press mimeograph typewriter linotype 31
32. The stage in the development of a butterfly which resembles a worm is the pupa cocoon chrysalis larva 32
33. The fourth book of the Bible is Genesis Numbers Exodus Job 33
34. Mosaics are designs churches memorials tombs 34
35. Buddhism had its origin in Arabia China India Egypt 35
36. Michelangelo was noted as a painter pianist musician sculptor 36
37. The Louvre is a church museum burial-place stadium 37
38. The largest of the pyramids is called Cephren Sphinx Cheops Mycernus 38
39. To make acetylene gas you mix water with calcium carbide sodium sulphate potassium chloride magnesium nitrate 39
40. Water enters the roots of plants by capillarity osmosis evaporation solution 40

Section III

Scoring Methods Used

The scoring methods of a test are largely determined by the purpose for which the test was developed. In the case of the present series of tests the purpose was to have an instrument that would bring the questionable attitudes and interests of the subject to light. Of course, it would not be impossible to recognize some extremely worthwhile and commendable interests of the subject in the responses that he gave; but neither in its aims nor its methods was this study directly concerned with the commendable and healthy character traits of the subject. It was his potentially delinquent interests that were sought. Whether or not a response betrayed a questionable, undesirable, unhealthy interest or preference, therefore, became the criterion for evaluation of the test responses. *A high score would be indicative of a marked degree of interest in, or preference for, matters questionable; a low score a more healthy-minded and desirable disposition.*

Test I—Forms A and B (Exercises 1 and 2 on the blanks).

Score is the number of fictitious titles checked. The fictitious titles are:

Form A.	Form B.
The Underground Patrol	The Flagman at Signal Rock
Alaskan Gold Stories	The Revolt at Bunker Hill
The Boy Thief	Blind Tom's Adventures
The Pirate's Revenge	The Death of Marco Polo
Kit Carson's Last Ride	The Mysterious Minstrels
Tom Wilson and His School	William Chesterfield
The Prize-Fighter's Story	True to His School
The Captain's Daughter's Secret	Campaigning in Argentina
Sea-side Adventures	Sunk Without a Trace
Scouting in Strange Lands	The Friday Murders

Test II—Character Preference, Forms A and B (Exercises 3 and 5 on the blanks).

In this test as well as the next—Reading Preference—the responses of the subject were scored in terms *of the square of their deviation from the values derived from the rankings given by a group of competent judges.* First of all, the character sketches and the lists of books were submitted to twenty com-

petent judges—professors, graduate students, juvenile court workers—all of whom gave the material their careful consideration. They were asked to rank the characters in the order of their worthwhile influence on the healthy and desirable development of boys of ages ten to fourteen, presuming that each of the boys described could be cultivated as a friend or pal by the other boys, whose development was being considered. A definite amount of agreement was noted between the rankings given by the different judges in respect of the relative positions of the different characters, so the percentages of judgments that character A was more worthwhile than character B, and B preferable to C, and so on (as the case may be), were calculated. From these measures of relative position a series of values was obtained for the characters, the values being so many Standard Deviations of the distribution, of which the distribution of greater judgments is the integral (see Thorndike, *Mental and Social Measurements,* page 122 ff, and Kelley, *Statistical Methods,* page 373 ff), *e.g.,* 80 per cent preferred character E to character C, which equals .841621 sigma; 85 per cent preferred character C to character G, which equals 1.036433 sigma; 85 per cent preferred character G to character A, which equals 1.036433 sigma. And so on for the others.

Thus a graded series of values for the different characters could be developed. If E were given a value of 0, C would be .8; G, 1.8; A, 2.8, and so on. In order to have a series of values that would be free from decimal fractions, each of the series, *i.e.,* for both Forms of the tests, was multiplied by an appropriate number to yield a series of integers. The following are the standard rankings, together with the corresponding values, for the different items of the two Forms:

Form A		Form B	
Ranking of characters as given in test:	Values	Ranking of characters as given in test:	Values
4	8	3	6
6	11	7	17
2	2	5	15
5	9	1	0
1	0	6	15
7	13	2	3
3	5	8	19
8	13	4	10

Test III—Reading Preference, Forms A and B (Exercises 4 and 6 on the blanks).

The score is the *sum of the square of the deviations from the values derived from the rankings given by competent judges.*

The values for the different items in the series in this test were derived in exactly the same way in which those for the previous test. The following are the standard rankings, together with the corresponding values for the different items of the two forms:

Form A		Form B	
Ranking of books as given in the list	Values	Ranking of books as given in the list	Values
4	3	4	2
6	6	9	11
2	0	2	1
8	8	8	10
1	0	7	9
9	9	1	0
10	10	5	3
3	2	10	12
7	8	3	1
5	5	6	5

Sample of Scoring Method for Tests II and III.

Supposing a subject ranked the characters of Test II, Form A, in the following manner: 3 2 1 8 4 5 7 6; then, to get the deviation for each item the value for 3 is found, viz., 5; but the item that is ranked 3 ought to have been ranked 4, whose value is 8. The score on the first item, therefore, is the square of 8 — 5, which is 9. The same procedure is followed for each of the other items, and the final score will be the sum of 9, 49, 4, 16, 64, 4, *i.e.*, 226.

Test IV—Activity Preference (Exercise 7 on the blanks).

The score on this test is the *number of questionable activities marked.* Since there was only one form for this test, the scores on the odd and the even groups were recorded separately.

Test V—Controlled Association (Exercise 8 on the blanks).

The score here is *the number of questionable reactions given.* The scores on the odd and the even items were recorded separately.

Test VI—Offense Rating, Forms A and B (Exercises 9 and 10 on the blanks).

The score in this test is the *sum of the square of the deviation in ranking for each item from the standard ranking developed by Clark in his Offense Rating Scale.* The standard ranking of the items as arranged in both forms of the tests is as follows:

Form A		Form B	
(a)	3	(a)	6
(b)	8	(b)	2
(c)	10	(c)	9
(d)	2	(d)	4
(e)	6	(e)	7
(f)	1	(f)	1
(g)	9	(g)	10
(h)	4	(h)	3
(i)	7	(i)	5
(j)	5	(j)	8

Test VII—Overstatement, Forms A and B (Exercises 11 and 12 on the blanks).

The score on this test is expressed as *percentages of overstatement or understatement.* This is calculated in the following manner:

Score on Part I—the points which the subject gave himself;
Score on Part II—(the rights minus 1/3 the wrongs) times 2;
Final Score—*the per cent that the score of Part II is less or more than the score of Part I.*

Thus:

A subject gave himself 50 points on Part I. He had *20* items correct; *6* were wrong. His score on Part II was *20 minus 1/3 of 6,* which is *18;* multiplied by *2,* viz., *36.* His final score, therefore, was overstatement to the extent of *28* per cent.

CHAPTER IV

DESCRIPTION OF EXPERIMENT

1. *A Preliminary Experiment.*

Because of the untried tests and test methods suggested in the previous chapters, it was thought advisable to make a preliminary inquiry, in order to see whether the methods and materials were such as to warrant development and use, and more especially was it necessary to find out whether the tests were not merely tests of mental ability.

In order to try out the tests that had been developed, two of the tests of the present series, viz., Test II, Character Preference, and Test III, Reading Preference, were given, in the winter quarter of 1922, to 259 boys, ages from ten to fourteen, from three schools in different environments in San José and Menlo Park. Later on during the Spring Quarter, Test VII, Overstatement, was given to the two schools in San José. The following was the outcome of this preliminary inquiry:

One form of the National Intelligence Test was given to all the subjects, and in addition the teachers were asked to rate the boys they knew on a five point scale on each of the following: attitude toward associates; towards authority and institutions; towards duties; towards property; and attitude regarding their own persons.

1. The method of giving the tests proved to be perfectly satisfactory. The subjects were at their ease; there was no evidence of suspicion concerning the implications of their responses; and the materials proved to be of interest to the boys without arousing disgust of any kind—as materials of this kind could readily do. Remarkable differentiation was evident on the test scores between the group and between individuals.

2. The tests proved themselves to be markedly reliable, the reliability for Test II for different groups ranging from .64 to .80.

The reliability for the boys from the Training School, which is a representatively average school, was .66. In the case of Test III the reliability ranged from .55 to .73. The reliability for the training school group was .67. It must be explained that the items of both these tests were printed on cards. The subject then had to arrange these cards so that the order gave the order of his preferences. This was a very satisfactory procedure; the task remained a novel one to the subjects throughout. It was to be regretted that the procedure could not be continued in the present experiment, because of the amount of time entailed in scoring the responses. It would appear that the original method of using cards is the more satisfactory one. The method used in the final experiment has the disadvantage that, when the second form of the test is given, the task is no longer a new one, and the subject is inclined to make his choice rather hurriedly, and with not the same deliberation with which he made his choices on the first form.

The reliability for the Overstatement Test, *i.e.*, Test VII, came to be .56. This, however, was the first draft of the test. It was later reorganized on the basis mentioned in the previous chapter. The reliability subsequently turned out to be much higher.

3. The correlation between Tests II and III and the National Intelligence Tests for different groups ranged from .088 to .48.

4. The intercorrelation between Tests II and III for the Training School group was .511.

5. The correlation between teachers' ratings on limited groups and test scores ranged from .21 to .32. The higher agreement between teachers' ratings and test scores came from situations where a teacher in the school in the poorer environment knew the boys she was rating, these boys having been either juvenile court cases or problem cases in the school.

These results were undoubtedly encouraging. Since the same subjects could not be used for development of the tests, after the overstatement had once been given to them, a new group of subjects had to be selected. This led to the planning of the subsequent experiment.

2. *The Final Experiment.*

In planning the main experiment some of the findings and experiences of the preliminary experiment were utilized. First of all, because of the fact that teachers do not know all of the children in their classes well enough to be able to give a reliable rating on the moral development of each child, or even of a fair majority of them; and because the teacher is more likely to be acquainted with the extremes in her grade—whether it is concerning a question of intelligence, character, or what not—it was decided to ask the teachers to select the extremes of her group for the actual experiment (see below, actual group selected). Again, because of the marked differences found in the previous experiment in the average scores for the groups from the different communities, and because of the positive relationship that exists between poor environment and delinquent behavior, it was thought desirable to select subjects from differing social and educational environments, in order to make a comparative study of the differentiation that might be made by the tests.

Another matter of consideration was the factor of age. The original experiment seemed to indicate a slight decrease in scores (*i.e.,* moral improvement) from age ten to fourteen. The literary character of the test materials might, or might not, account for such a difference. Whether or not moral habits have become thoroughly established at the age of ten, or to what extent the directive forces of educational influences—the home, the school, associates, etc.—have been successful in bringing about the control and inhibition of questionable tendencies at the age of fourteen is not known. In fact, very little is known about the nature of the moral development of boys during these years under discussion. As stated in Chapter II, the mode of the age distribution of boys who appear before the court for the first time on some or other charge of delinquency is *thirteen,* with fourteen, perhaps, as the mode of the ages of boys actually in reform schools. It was therefore deemed advisable to select thirteen-year-old boys as one of the groups to be studied. In order to make a comparison with an earlier age, eleven-year-old boys were selected as the second age group. This was also done because of the fact pre-

viously noted, viz., that the definite delinquent departure of many juvenile court charges can be traced back a year or two prior to their apprehension. The object, then, of selecting eleven-year-olds was, in part, to investigate whether, by means of a test method, it would be possible to find individuals of the group that showed signs of persistently marked interest, at that early age, in undesirable and questionable activities (a knowledge of such interest could be turned by the thoroughgoing educator to excellent purpose in the prevention of further delinquent development through the direction of the boy's interests and energies to more worthwhile pursuits). The most desirable procedure would, of course, have been to take boys of every age, say from nine up to sixteen. Such a program of selection was outside the possibility of the present experiment, because of the tremendous amount of time and money it would have required. The following were the *groups* and *subjects selected:*

1. The 25 per cent most reliable, stable, healthy-minded, and the 25 per cent least reliable, stable, and healthy-minded eleven-year-old and thirteen-year-old boys, from grades 4 to 8, in a socially and educationally privileged community in Los Angeles. These boys were selected from four different schools and communities which were judged by the city school authorities to be of approximately equal standing with regard to the educational and social opportunities. These four sub-groups will hereafter be referred to as: 13 years A_1 (*i.e.,* the most reliable group); 13 years A_2 (*i.e.,* the least reliable group); 11 years A_1 (*i.e.,* the most reliable group); and 11 years A_2 (*i.e.,* the least reliable group). The selection of the subjects in each school was made by the class teacher. She selected the 25 per cent most reliable and the 25 per cent least reliable eleven-year-old and thirteen-year-old boys in her grade. This was an easy task, because a teacher often had only four boys of the required age in her grade, which meant that she had to send in two boys.

2. The 25 per cent most reliable, stable, healthy-minded, and the 25 per cent least reliable, stable, and healthy-minded eleven-year-old and thirteen-year-old boys, from grades 4 to 8, in a socially and educationally *less* privileged community in Los Angeles,

formed the second group. These subjects were selected from five schools and communities which, too, were considered by the city school authorities to be homogeneous as regards social and educational opportunity. These four sub-groups will be referred to hereafter as:

13 years B_1 (*i.e.*, the most reliable group).
13 years B_2 (*i.e.*, the least reliable group).
11 years B_1 (*i.e.*, the most reliable group).
11 years B_2 (*i.e.*, the least reliable group).

The actual selection of the subjects was made here in the same manner as described in the previous paragraph for the A group.

3. A group of 50 boys, of ages twelve, thirteen, and fourteen, from two Parental Schools in Los Angeles, constituted the third group. There was not a large enough number of thirteen-year-olds, and only very few eleven-year-olds; it was therefore thought best to take the group mentioned. This selection, too, it was thought, would more likely approach the mental age level of the boys selected in the communities mentioned above. It might be explained that the boys in the parental schools were those boys that had been before the juvenile court on some or other minor charge not serious enough for commitment to a reform school. They are a very heterogeneous group, many of them exceedingly incorrigible, and "hard boiled." They are full-fledged delinquents, with none of the acquired attitudes of control that are to be noticed with the boys of the Whittier State School.

4. The fourth group was a group of 36 boys, ages thirteen and fourteen, from the Whittier State School. The majority of these boys had been in Whittier a year or more; they were placed there by the order of the court—in the majority of cases for some serious or repeated offense. These ages were selected for the same reason as mentioned in connection with the Parental School group.

In almost every school the boys asked why they only were selected for the task. It was always told them, that to take all the boys would be an impossible task; the examiner was interested in boys generally, and that for the particular task a sample

would suffice. The teachers readily promised not to tell the boys what the criterion of her selection was.

Tests Given.

In addition to the series of tests reported in Chapter III, Form B, Scale 2, of the "National Intelligence Tests" was given. It was regretted that because of a lack of time a second Form, or a Form of the "Terman Tests of Mental Ability" could not be given. The school program could hardly be disturbed on a second day, when a period of two and one-half hours had been granted the previous day.

The tests were all given by the examiner to the groups that were finally selected from the schools. The time taken for the whole series was from about an hour and forty-five minutes to two hours; there was no time limit set. This was followed by the Intelligence Test. The sitting would appear to be long; however, with short breaks of a few minutes, and the constant change of materials, the boys seemed to enjoy the task very thoroughly. After the task was over they talked quite freely about the exercises, but not a single guess as to the implications of their responses was correct.

CHAPTER V

RECORD OF TEST SCORES

The present chapter is a record of the scores of all the groups on all the tests. It must be noted that a low score indicates a stable and healthy-minded type of boy; a high score a type that has many questionable interests and relations.

Legend.

A_1 Most stable, healthy-minded, reliable, from a privileged community.

A_2 Least stable, etc., from a privileged community.

B_1 Most stable, etc., from a less privileged community.

B_2 Least stable, etc., from a less privileged community.

Special. Boys from the Parental Schools.

Whittier. Boys from the Whittier State School.

TABLE I: SCORES OF FIFTY THIRTEEN-YEAR-OLD BOYS, GROUP A_1, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	B	Total	Character Preference 2. A	B	Total	Reading Preference 3. A	B	Total	Activity Preference 4. A	B	Total	Controlled Association 5. A	B	Total	Offense Rating 6. A	B	Total	Over-statement 7. A	B	Average
1.	1	6	13–1	78.2	10–8	81	1	2	3	164	492	656	210	358	568	0	2	2	5	5	10	40	54	94	41	42	41
	2	8	13–4	144.1	17–3	129	6	10	16	90	96	186	76	148	224	1	1	2	1	1	2	24	16	40	59	57	58
2.	1	8	13–6	142.8	17–2	127	0	1	1	8	42	50	38	72	110	1	1	2	0	0	0	4	42	46	27	29	28
	2	8	13–1	153.3	17–3	132	0	0	0	104	62	166	58	108	166	0	1	1	1	1	2	20	46	66	55	49	52
	3	6	14–10	83.0	11–0	74	0	0	0	202	60	262	216	436	652	0	3	3	2	3	5	104	108	212	23	21	22
	4	8	13–1	110.5	12–11	99	0	0	0	136	118	254	6	20	26	0	0	0	0	0	0	0	30	30	31	51	41
	5	8	13–7	103.0	12–4	91	1	2	3	138	50	188	16	32	48	1	0	1	0	0	0	22	24	46	49	52	51
	6	8	13–8	154.4	17–3	126	1	2	3	50	78	128	136	40	176	0	1	1	1	1	2	16	24	40	31	47	39
	7	7	13–3	85.3	11–2	84	0	1	1	248	378	626	76	356	432	2	3	5	5	6	11	14	20	34	56	51	53
	8	8	13–11	143.1	17–2	123	0	0	0	118	8	126	8	0	8	0	0	0	1	0	1	34	12	46	47	51	49
	9	8	13–6	145.1	17–3	128	0	0	0	266	134	400	60	14	74	0	0	0	0	1	1	8	34	42	25	36	31
	10	7	13–5	131.1	14–8	109	0	0	0	150	42	192	118	12	130	1	0	1	0	1	1	14	52	66	32	20	26
	11	7	13–8	49.2	9–2	68	0	0	0	260	184	444	168	136	304	0	0	0	2	7	9	80	118	198	23	8	15
	12	7	13–4	100.2	12–2	91	1	0	1	34	62	96	36	14	50	0	0	0	1	1	2	8	8	16	18	30	18
3.	1	6	13–7	103.8	12–5	92	0	0	0	184	552	736	174	448	622	3	1	4	5	6	11	24	54	78	82	92	87
	2	6	13–7	106.4	12–6	92	0	0	0	76	184	260	100	110	210	2	1	3	4	6	10	60	76	136	43	80	62
	3	6	13–7	133.0	15–1	111	0	0	0	112	42	154	120	158	278	0	1	1	2	3	5	58	24	82	41	41	41
	4	6	13–11	87.4	11–4	82	0	0	0	128	112	240	34	12	46	1	0	1	1	1	2	18	40	58	57	88	72
	5	6	13–1	111.4	12–0	99	0	0	0	14	18	32	107	544	651	1	1	2	1	1	2	32	48	80	66	100	83
	6	6	13–4	84.9	11–2	84	0	0	0	428	472	902	120	492	612	1	4	5	2	0	2	98	66	164	32	57	45

4.	1	9	13–9	158.6	17–3	126	1	0	1	32	42	74	34	18	52	0	0	0	0	1	1	30	18	48	38	24	31
	2	9	13–4				8	2	10	34	132	166	12	4	16	0	1	1	0	0	0	4	8	12	41	43	42
	3	8	13–1	133.9	15–3	115	0	1	1	18	24	42	62	50	112	2	1	3	3	3	6	34	34	68	83	51	67
	4	9	13–10	114.7	13–4	97	0	0	0	86	224	310	16	32	48	0	0	0	0	0	0	18	12	30	39	48	43
	5	7	13–0	149.3	17–3	133	0	0	0	42	96	138	162	190	352	0	0	0	0	0	0	56	34	90	38	56	47
	6	9	13–6	164.9	17–3	128	3	2	5	10	76	86	18	2	20	1	1	2	0	0	0	48	6	54	19	13	16
	7	9	13–11	168.9	17–3	124	1	0	1	50	84	124	70	16	86	0	1	1	0	0	0	8	30	38	39	20	30
	8	9	13–4	172.0	17–3	129	0	0	0	2	58	60	16	8	24	0	0	0	0	2	2	16	2	18	44	38	41
	9	7	13–1	143.7	17–3	122	1	0	1	106	18	124	24	14	38	0	0	0	0	0	0	8	12	20	52	50	51
	10	8	13–2	173.1	17–3	131	0	0	0	68	74	142	254	250	504	0	0	0	0	0	0	82	40	122	21	28	24
	11	8	13–2	152.3	17–3	131	0	0	0	238	24	262	192	184	376	1	2	3	5	3	8	8	40	48	30	53	42
	12	8	13–5	166.7	17–3	128	0	0	0	34	18	52	20	36	56	1	0	1	0	0	0	4	2	6	–2	0	–1
	13	8	13–4	147.9	17–3	129	0	0	0	462	702	1164	286	364	650	5	3	8	10	9	19	30	24	54	39	15	27
	14	8	13–2	151.7	17–3	131	0	0	0	176	308	484	318	308	626	3	4	7	6	5	11	84	26	110	22	35	28
	15	7	13–10	121.4	13–10	100	2	2	4	80	96	176	56	24	90	0	1	1	2	2	4	70	38	108	47	52	50
	16	8	13–9	155.5	17–3	126	3	3	6	18	42	60	10	30	40	0	0	0	0	0	0	14	20	34	19	38	28
	17	8	13–8	163.9	17–3	126	0	1	1	288	58	346	108	134	242	2	1	3	3	0	3	10	22	32	4	20	12
	18	7	13–4	163.1	17–3	129	0	2	2	228	62	290	12	140	152	1	0	1	1	1	2	12	14	26	31	42	37
	19	8	13–7	161.0	17–3	127	1	2	3	8	380	388	74	142	216	2	2	4	1	2	3	36	26	62	33	31	32
	20	8	13–4	120.8	13–10	103	8	6	14	278	310	588	108	252	360	2	2	4	4	4	8	28	98	126	61	80	70
	21	7	13–5	102.2	12–3	91	0	0	0	166	400	566	112	168	280	2	2	4	8	8	16	220	134	354	92	93	93
	22	7	13–8	133.1	15–1	110	4	2	6	8	8	16	22	14	36	0	0	0	0	1	1	32	20	52	64	52	58
	23	7	13–0	103.2	12–4	95	0	0	0	164	76	240	118	422	540	3	2	5	4	4	8	22	24	46	47	59	53
	24	7	13–3	131.3	14–8	111	0	0	0	266	238	504	334	412	746	0	1	1	0	0	0	24	22	46	24	51	37
	25	8	13–5	131.4	14–8	109	0	1	1	232	98	330	90	188	278	0	0	0	1	1	2	40	48	88	44	50	47
	26	8	13–2	168.5	17–3	131	0	0	0	94	8	102	118	160	278	0	2	2	0	0	0	38	28	66	31	13	22
	27	7	13–6	85.6	11–3	127	0	0	0	278	164	442	202	180	382	2	0	2	0	2	2	38	36	74	63	54	59
	28	7	13–9	116.3	13–6	98	0	2	2	254	96	350	172	152	324	1	2	3	0	0	0	10	74	84	70	80	75
	29	7	13–2	112.6	13–2	100	0	1	1	104	198	302	60	32	92	2	0	2	1	1	2	70	28	98	47	80	63
	30	8	13–5	157.3	17–3	128	3	2	5	42	58	100	96	18	114	0	0	0	0	1	1	26	12	38	42	20	31
Mean:			13–5		14–11	111	.9	.94	1.84	135.5	147.2	282.7	101.06	149.28	250.3	.9	.96	1.84	1.6	1.9	3.5	35.9	36.5	72.5	41.2	45.8	43.5

TABLE II: SCORES OF THIRTY-SEVEN THIRTEEN-YEAR-OLD BOYS, GROUP A_2, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	1. B	1. Total	Character Preference 2. A	2. B	2. Total	Reading Preference 3. A	3. B	3. Total	Activity Preference 4. A	4. B	4. Total	Controlled Association 5. A	5. B	5. Total	Offense Rating 6. A	6. B	6. Total	Over-statement 7. A	7. B	Average
1.	1	6	13–4	84.9	11–2	84	1	0	1	58	182	240	54	20	74	1	0	1	0	0	0	28	76	104	49	51	50
	2	6	13–5	101.5	12–3	91	3	2	5	352	860	1212	398	388	786	1	3	4	5	4	9	110	81	191	50	86	68
	3	6	13–4	143.4	17–2	128	6	8	14	308	448	756	228	534	762	4	2	6	4	4	8	154	102	256	46	80	63
2.	1	8	13–10	169.5	17–3	125	0	0	0	134	240	374	334	600	934	0	0	0	0	0	0	6	14	20	14–	19–	16–
	2	6	13–2	126.8	14–3	118	2	1	3	300	798	1098	188	520	708	1	3	4	3	1	4	22	16	38	17	18	17
	3	8	13–6	153.7	17–3	127	0	0	0	106	340	446	354	4	358	1	1	2	2	1	3	16	22	38	79	19	49
	4	6	14–1	87.2	11–4	81	0	0	0	80	62	142	20	102	122	3	2	5	0	4	4	56	46	102	31	31	31
	5	7	13–2	97.4	11–11	91	0	0	0	122	32	154	186	10	196	1	1	2	3	0	3	22	12	34	15	15	15
	6	8	13–9	140.6	16–8	122	0	0	0	62	192	254	34	6	40	0	0	0	1	4	5	10	92	102	29	64	47
	7	7	13–6	154.3	17–3	127	3	4	7	230	692	922	366	608	974	5	5	10	8	3	11	22	26	48	69	46	57
	8	8	13–1	145.4	17–3	132	0	0	0	120	130	250	178	248	426	1	2	3	1	1	2	10	32	42	22	51	37
3.	1	6	13–1	104.6	12–5	95	0	0	0	54	434	488	102	208	310	1	0	1	0	3	3	38	54	92	31	38	34
	2	5	13–2	94.5	11–9	89	0	0	0	144	104	248	80	124	204	1	1	2	1	1	2	10	12	22	84	78	81
4.	1	8	13–5	143.7	17–2	128	7	8	15	42	250	292	20	30	50	0	1	1	0	1	1	40	38	78	82	75	79
	2	7	13–4	114.5	13–3	99	0	0	0	190	86	276	172	76	248	0	2	2	1	1	2	210	206	416	46	55	50
	3	7	13–1	117.9	13–7	104	0	0	0	106	132	238	180	240	420	1	2	3	2	4	6	16	54	70	47	74	61
	4	8	13–6	129.6	14–7	108	0	0	0	108	24	132	78	34	112	0	2	2	0	0	0	4	32	36	44	33	38
	5	7	13–10	159.5	17–3	125	1	0	1	122	54	176	42	52	94	1	1	2	0	0	0	8	56	64	29	49	39
	6	7	13–7	131.0	14–8	108	0	1	1	166	724	890	58	474	532	2	1	3	4	2	6	10	10	20	80	66	73

7	9	13–10	158.0	17–3	125	3	3	6	50	242	292	16	12	28	0	2	2	3	1	4	88	24	112	43	27	35
8	8	13–11	127.5	14–3	102	5	5	10	254	168	422	240	490	730	2	1	3	0	1	1	34	62	96	69	82	75
9	7	13–7	129.7	14–6	107	4	1	5	122	58	180	38	92	130	1	1	2	2	2	4	12	20	32	48	54	51
10	9	12–11	135.7	15–8	121	0	0	0	42	188	230	46	14	60	0	0	0	1	0	1	44	82	126	63	17	40
11	8	13–7	157.9	17–3	127	1	1	2	60	78	138	22	8	30	0	0	0	0	0	0	44	22	66	32	23	27
12	8	13–1				2	1	3	224	50	274	148	194	342	1	3	4	1	1	2	14	2	16	46	51	49
13	8	13–11	156.8	17–3	124	0	0	0	92	8	100	12	26	38	1	1	2	1	1	2	22	14	36	30	39	34
14	8	13–6	145.4	17–3	127	1	0	1	214	62	276	40	12	52	1	0	1	1	1	2	18	26	44	14	14	14
15	8	13–7	163.6	17–3	127	0	0	0	90	148	238	66	272	338	1	1	2	1	1	2	40	28	68	22	20	21
16	7	13–9	143.0	17–2	125	0	0	0	106	94	200	210	424	634	2	0	2	0	1	1	32	18	50	45	68	57
17	7	13–1	130.0	14–6	111	2	3	5	80	18	98	216	16	232	1	1	2	2	0	2	8	6	14	63	59	61
18	7	13–2	137.3	15–10	120	0	0	0	58	50	108	54	20	74	0	0	0	0	0	0	18	12	30	55	67	61
19	7	13–9	161.0	17–3	125	5	6	11	194	94	288	106	128	234	1	0	1	1	1	2	16	42	58	45	54	49
20	7	13–2	107.5	12–8	96	5	6	11	134	104	238	128	178	306	0	0	0	2	1	3	20	18	38	81	60	70
21	7	13–8	128.3	14–4	105	3	2	5	86	422	508	22	22	44	0	1	1	2	4	6	54	42	96	43	53	48
22	7	13–4	127.8	14–4	107	1	0	1	50	140	190	114	56	170	2	0	2	0	1	1	30	28	58	15	79	47
23	8	13–3	162.3	17–3	130	2	2	4	336	302	638	204	462	666	3	4	7	1	2	3	12	22	34	56	35	46
24	8	13–6	141.1	16–9	124	2	0	2	86	0	86	64	4	68	2	0	2	0	1	1	36	4	40	69	61	65
Mean:		12–5		14–10	110	1.59	1.45	3.05	137.3	216.4	353.8	130.2	181.2	311.5	1.13	1.18	2.32	1.43	1.43	2.86	36.05	39.25	75.32	45.27	47.91	46.59

TABLE III: SCORES OF FORTY-THREE THIRTEEN-YEAR-OLD BOYS, GROUP B_1, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1.			Character Preference 2.			Reading Preference 3.			Activity Preference 4.			Controlled Association 5.			Offense Rating 6.			Over-statement 7.		
							A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Average
1.	1	6	13–2	135.	15–6	118	1	0	1	356	202	558	238	224	462	3	2	5	2	0	2	4	12	16	60	67	64
	2	6	11–3	98.	12–	91	5	3	8	104	316	420	44	396	440	0	1	1	0	0	0	140	86	226	88	98	93
	3	8	13–1	151.7	17–3	132	0	0	0	104	96	200	58	24	82	1	1	2	1	2	3	6	24	30	–37	33	–2
	4	7	13–6	152.	17–3	127	3	2	5	30	168	198	28	18	46	1	0	1	1	3	4	40	6	46	42	46	44
	5	7	13–3	124.6	14–2	107	1	0	1	54	80	134	24	54	78	1	0	1	0	0	0	4	22	26	75	60	67
	6	7	13–8	120.4	13–9	101	0	2	2	8	184	192	54	32	86	1	0	1	0	1	1	42	114	156	26	21	24
	7	8	13–0	150.7	17–3	133	4	1	5	8	148	156	4	4	8	0	0	0	0	0	0	20	32	52	53	63	58
2.	1	6	13–9	61.5	9–9	71	2	6	8	142	184	326	136	318	454	2	4	6	6	7	13	112	64	176	79	84	81
	2	8	13–8	122.1	13–11	102	0	0	0	138	56	194	72	138	210	1	0	1	2	7	9	80	18	98	58	74	66
	3	8	13–0	129.7	14–6	112	1	0	1	80	0	80	36	12	48	0	1	1	0	0	0	4	36	40	24	27	26
	4	7	13–6	119.3	13–8	101	1	0	1	62	142	204	10	24	34	2	0	2	0	1	1	8	66	74	9	47	28
	5	8	13–4	149.9	17–3	129	1	0	1	54	0	54	46	44	90	0	1	1	0	0	0	12	6	18	38	22	30
	6	7	13–0	109.8	12–10	99	1	0	1	114	78	192	58	254	312	1	0	1	1	1	2	46	66	112	29	43	36
	7	5	13–3	72.8	10–4	78	0	0	0	62	502	564	64	42	106	2	0	2	1	3	4	46	24	70	62	56	59
3.	1	6	13–8	63.4	9–10	72	0	0	0	142	384	526	38	110	148	0	4	4	8	6	14	120	128	248	73	82	77
	2	7	12–7	101.0	12–3	92	0	1	1	176	98	274	80	118	198	2	2	4	0	1	1	80	26	106	78	70	74
	3	7	13–6	114.7	13–4	99	3	1	4	122	142	264	138	186	324	1	0	1	1	0	1	104	58	162	65	60	63
	4	6	13–0	92.7	11–8	90	0	1	1	134	166	300	172	262	434	0	2	2	1	2	3	26	50	76	71	87	79
	5	8	13–3	155.0	17–3	130	0	2	2	170	438	608	262	192	454	1	2	3	2	4	6	72	28	100	36	46	41
	6	7	12–9	110.0	12–11	101	0	0	0	128	62	190	96	90	186	1	1	2	1	2	3	28	34	62	33	32	32

	7	7	13–6	142.0	16–11	125	2	3	5	248	80	328	294	260	554	2	0	2	1	2	3	34	56	90	77	65	71
	8	8	14–1	118.8	13–8	97	0	2	2	142	24	166	28	44	72	1	1	2	1	0	1	16	32	48	32	45	39
	9	8	13–11	131.4	14–9	106	1	0	1	54	130	104	322	204	526	1	1	2	2	1	3	16	16	32	34	47	41
	10	7	13–6	120.6	13–10	102	0	1	1	146	26	172	54	50	104	1	0	1	0	1	1	30	58	88	91	72	81
	11	7	13–4	141.2	16–9	126	2	2	4	50	24	74	54	14	68	1	0	1	0	0	0	36	36	72	46	44	45
	12	8	13–11	132.2	14–11	107	0	1	1	232	204	436	196	278	474	1	1	2	1	1	2	8	32	40	22	50	36
	13	7	14–0	124.9	14–2	101	0	0	0	184	128	312	88	262	350	0	0	0	0	3	3	18	58	76	61	49	55
4.	1	8	13–6	148.9	17–3	128	1	2	3	66	62	128	52	72	124	1	1	2	0	2	2	24	12	36	29	38	34
	2	8	13–11	130.0	14–7	105	0	0	0	82	76	128	76	274	350	2	1	3	0	4	4	2	22	24	74	48	61
	3	8	13–1	143.2	17–3	132	0	1	1	86	94	180	50	32	82	1	0	1	1	0	1	10	58	68	46	67	56
	4	8	13–7	138.0	16–1	118	6	3	9	112	278	390	106	164	270	0	2	2	1	1	2	10	52	62	46	72	59
	5	7	13–7	85.1	11–2	77	1	3	4	98	274	372	236	214	450	3	3	6	4	5	9	60	66	126	78	82	80
	6	8	13–4	151.0	17–3	129	1	1	2	54	202	256	10	88	98	0	1	1	1	0	1	4	22	26	7	34	20
	7	8	13–0	142.0	16–11	130	0	1	1	58	42	100	36	32	68	3	1	4	0	0	0	22	20	42	48	52	50
	8	8	13–1	143.2	17–3	132	3	2	5	244	176	420	138	192	330	0	0	0	3	2	5	22	12	34	38	49	44
	9	7	13–4	118.7	13–8	102	0	1	1	136	416	552	91	133	224	1	0	1	1	0	1	12	40	52	32	40	36
	10	8	13–2	127.0	14–3	108	0	0	0	152	178	330	110	140	250	1	0	1	3	2	5	60	130	190	53	42	48
	11	7	13–11	103.9	12–5	89	8	3	11	136	310	446	98	122	220	1	1	2	1	2	3	16	36	52	60	80	70
5.	1	8	13–5	140.8	16–8	124	0	0	0	34	8	42	72	16	88	1	0	1	0	0	0	16	46	62	33	31	32
	2	8	13–7	163.6	17–3	127	0	0	0	2	26	28	24	54	78	0	1	1	1	0	1	12	24	36	18	11	15
	3	8	13–1	162.7	17–3	132	0	0	0	154	128	282	24	14	38	1	1	2	3	0	3	8	26	34	23	4	13
	4	7	13–1	81.5	10–11	84	4	5	9	282	58	340	168	314	482	3	1	4	3	8	11	46	56	102	61	75	68
	5	7	13–8	89.3	11–5	84	5	3	8	146	78	224	134	444	578	1	0	1	2	3	5	30	70	100	74	69	71
Mean:			13–5		14–6	108	1.3	1.2	2.6	118.3	150.4	268.7	95.8	138.6	234.4	1.07	.86	1.93	1.30	1.79	3.09	35	43.7	78.8	47.5	53.1	50.3

TABLE IV: SCORES OF FORTY THIRTEEN-YEAR-OLD BOYS, GROUP B_2, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1.			Character Preference 2.			Reading Preference 3.			Activity Preference 4.			Controlled Association 5.			Offense Rating 6.			Over-statement 7.		
							A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Average
1.	1	6	13–10	125.0	14–2	103	0	0	0	284	552	836	170	214	384	4	4	8	5	7	12	48	22	70	17	84	50
	2	8	13–9	154.8	17–3	126	2	1	3	106	134	240	16	18	34	0	2	2	3	6	9	8	24	32	–6	10	2
	3	7	13–7	147.0	17–3	127	7	4	11	244	118	362	144	438	582	4	2	6	3	3	6	14	46	60	53	62	58
	4	7	13–7	153.6	17–3	127	1	0	1	106	166	272	152	60	212	2	2	4	5	1	6	30	26	56	62	51	56
	5	6	13–1	97.0	11–11	91	0	0	0	90	176	266	52	160	212	1	1	2	2	7	9	120	60	180	85	69	77
	6	7	13–1	105.8	12–6	96	0	0	0	378	474	852	384	446	830	3	4	7	1	2	3	52	60	112	54	52	53
	7	7	13–2	85.0	11–2	85	0	2	2	204	16	220	128	174	302	2	1	3	1	3	4	26	26	52	79	44	62
2.	1	5	13–11	36.9	8–7	62	3	4	7	256	788	1044	160	442	602	2	4	6	10	8	18	158	76	234	100	100	100
	2	5	13–11	78.3	10–9	76	2	1	3	332	728	1060	260	430	690	3	3	6	2	2	4	26	32	58	82	87	85
	3	7	13–	106.3	12–7	97	1	1	2	40	62	102	92	34	126	1	0	1	1	0	1	14	34	48	62	64	63
	4	8	13–	161.0	17–3	133	4	0	4	38	170	208	140	194	334	1	2	3	0	1	1	20	8	28	44	47	45
	5	8	13–10	130.9	16–6	119	0	0	0	158	78	236	10	234	244	2	1	3	2	1	3	22	30	52	11	41	26
	6	7	13–4	133.8	15–1	113	0	0	0	72	0	72	128	48	176	0	1	1	0	0	0	8	22	30	39	41	40
	7	6	13–9	116.5	13–6	98	0	0	0	150	40	190	102	50	152	1	1	2	1	0	1	62	56	118	93	61	77
	8	7	13–1	129.7	14–6	111	0	1	1	94	432	526	270	350	620	1	3	4	3	2	5	64	50	114	49	39	44
	9	5	13–10	63.0	9–10	71	0	0	0	552	184	736	266	104	370	2	3	5	8	8	16	92	222	314	73	100	87
3.	1	7	13–3	137.6	15–11	120	3	6	9	114	228	342	126	56	182	1	2	3	1	2	3	28	34	62	51	48	49
	2	6	13–9	97.0	11–11	87	0	0	0	180	336	516	76	262	338	0	1	1	1	2	3	52	76	128	44	52	48
	3	6	13–3	97.5	12–1	91	0	0	0	126	94	220	130	368	498	3	3	6	5	4	9	88	46	124	37	79	58
	4	7	13–11	165.0	17–3	124	0	0	0	54	78	132	20	114	134	0	2	2	1	1	2	12	26	38	19	58	39

	5	8	13–7	151.1	17–3	127	0	0	0	162	794	956	396	524	920	3	4	7	5	6	11	84	52	136	45	60	52
	6	7	14–1	105.5	12–6	89	1	1	2	356	664	1020	282	622	904	6	4	10	6	4	10	50	42	92	15	32	24
	7	6	13–9	88.1	11–5	83	9	8	17	68	218	286	208	256	464	1	1	2	0	5	5	14	72	86	71	0	35
	8	6	13–1	109.4	12–9	98	4	0	4	48	144	192	142	336	478	3	2	5	2	3	5	30	38	68	45	47	46
	9	7	13–9	129.5	14–7	106	0	0	0	124	94	218	210	38	248	2	4	6	4	3	7	22	26	48	40	85	63
	10	6	13–	122.1	14–11	115	5	8	13	118	396	514	116	324	440	1	1	2	0	0	0	14	26	40	67	64	65
	11	7	13–4	113.7	13–3	99	0	1	1	38	76	114	58	10	68	1	0	1	1	0	1	20	24	44	57	73	65
4.	1	8	13–8	143.3	17–2	126	1	0	1	184	146	330	110	416	526	1	0	1	0	3	3	14	20	34	60	88	74
	2	8	13–4	151.8	17–3	129	3	4	7	362	656	1018	378	706	1084	5	5	10	9	6	15	33	38	71	60	53	56
	3	7	13–5	133.7	15–3	113	0	1	1	104	26	130	86	20	106	0	0	0	2	0	2	14	22	36	37	0	19
	4	6	13–1	92.4	11–8	89	0	0	0	288	486	774	176	542	718	5	4	9	4	8	12	62	46	108	50	49	49
	5	8	13–6	156.8	17–3	127	0	0	0	128	298	426	164	208	372	1	0	1	0	1	1	33	44	77	39	50	45
	6	7	13–1	103.6	12–5	95	0	1	1	160	40	200	54	34	88	0	0	0	2	4	6	8	16	24	62	88	75
	7	8	13–5	132.0	14–11	111	3	7	10	114	94	208	258	108	366	1	1	2	0	2	2	24	12	36	76	76	76
	8	7	13–4	105.3	12–6	94	0	1	1	264	718	982	152	276	428	3	1	4	3	5	8	106	162	268	92	85	88
5.	1	8	13–7	157.0	17–3	127	0	0	0	336	86	422	154	552	706	1	1	2	2	1	3	2	6	8	31	–3	14
	2	8	13–8	163.4	17–3	126	2	0	2	110	18	128	16	16	32	0	0	0	1	0	1	14	14	28	49	37	43
	3	8	13–4	163.0	17–3	129	0	0	0	62	26	88	90	178	268	0	0	0	1	0	1	66	46	112	35	35	35
	4	7	13–4	116.2	13–5	101	9	5	14	122	42	164	202	258	460	1	0	1	8	10	18	26	76	102	76	75	76
	5	7	13–5	138.1	16–1	119	0	0	0	106	32	138	14	36	50	0	0	0	0	0	0	16	26	42	10	23	16
Mean:			13–6		14–4	106	1.5	1.42	2.9	170.8	247.7	418.5	152.3	241.4	393.7	1.7	1.75	3.45	2.6	2.0	5.6	39.9	49.6	84.5	51.6	55.1	53.4

TABLE V: SCORES OF FORTY-TWO ELEVEN-YEAR-OLD BOYS, GROUP A_1, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1.			Character Preference 2.			Reading Preference 3.			Activity Preference 4.			Controlled Association 5.			Offense Rating 6.			Over-statement 7.		
							A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Average
1.	1	5	11–1	86.5	11–4	102	0	0	0	102	122	224	40	66	106	0	0	0	2	4	6	26	46	72	78	60	69
	2	6	11–0	140.7	16–8	151	0	0	0	8	52	60	22	54	76	1	1	2	1	1	2	18	40	58	–5	7	1
	3	6	11–4	80.6	10–10	96	0	0	0	106	186	292	392	584	976	0	0	0	0	0	0	70	44	114	0	38	19
	4	6	11–7	98.2	12–0	103	0	0	0	130	128	258	282	386	668	1	2	3	1	1	2	42	62	104	90	59	75
	5	6	12–5	125.9	14–2	114	0	0	0	58	24	82	184	592	776	0	2	2	0	0	0	12	70	82	11	3	7
	6	6	11–5	141.8	16–10	147	2	1	3	16	0	16	78	60	138	1	0	1	1	0	1	62	22	84	48	50	49
	7	6	12–1	107.5	12–8	105	1	0	1	428	586	1014	247	170	417	1	1	2	3	0	3	16	50	66	–5	30	12
	8	6	11–6	130.4	14–6	126	0	0	0	14	26	40	100	330	430	2	1	3	0	0	0	16	34	50	56	46	52
	9	6	11–0	80.8	10–10	99	6	6	12	162	238	400	238	696	934	4	3	7	1	4	5	100	92	192	64	88	76
	10	5	11–1	85.2	11–2	101	0	0	0	130	110	240	10	82	92	1	0	1	0	0	0	10	58	68	4	28	16
2.	1	6	11–10	144.9	17–3	146	0	1	1	34	82	116	56	12	68	0	0	0	0	1	1	10	32	42	25	13	19
	2	7	11–10	138.3	16–1	135	0	0	0	278	356	634	242	272	514	1	2	3	2	2	4	16	46	62	59	51	55
	3	6	11–0	102.1	12–3	111	1	3	4	296	866	1162	326	444	770	5	6	11	6	11	17	36	24	60	95	70	83
	4	6	11–6	140.5	16–7	144	0	0	0	38	26	64	6	90	96	1	0	1	0	0	0	4	26	30	41	44	42
	5	6	11–11	145.3	17–3	145	0	0	0	174	338	512	152	336	488	1	3	4	1	0	1	28	8	36	50	31	41
	6	7	11–8	131.2	14–8	125	0	0	0	46	78	124	82	34	116	0	0	0	0	0	0	8	36	44	3	13	8
	7	6	11–9	136.0	15–8	133	6	6	12	316	418	734	72	260	332	4	2	6	0	3	3	52	40	92	71	76	73
	8	6	11–4	61.0	9–9	85	8	5	13	166	168	334	76	156	232	1	1	2	3	8	11	52	20	72	85	78	82
	9	5	11–8	81.9	10–11	94	4	2	6	12	78	90	38	12	50	2	0	2	5	5	10	50	52	102	78	82	80
	10	5	11–0	137.9	16–1	146	0	0	0	136	98	234	116	122	238	1	1	2	1	3	4	24	20	44	33	15	24
	11	6	11–7	113.8	13–3	114	0	1	1	234	300	534	162	282	444	3	1	4	0	0	0	44	34	78	39	69	54

	12	7	11–10	118.9	13–8	115	0	0	0	52	82	134	40	14	54	0	0	0	0	1	1	4	20	24	38	30	34
	13	7	12–0	106.0	12–6	104	0	0	0	166	188	354	38	124	162	1	0	1	1	3	4	30	18	48	50	30	40
	14	5	11–0	62.0	9–10	89	0	0	0	138	78	216	38	334	372	2	4	6	4	4	8	28	32	60	53	100	77
	15	7	11–5	156.0	17–3	151	0	0	0	82	130	212	78	130	208	0	1	1	0	0	0	20	28	48	24	19	22
	16	5	11–0	105.1	12–6	113	0	0	0	48	184	232	38	14	52	0	0	0	0	2	2	58	60	118	61	48	54
3.	1	6	11–6	148.1	17–3	150	0	0	0	174	78	252	46	96	142	0	1	1	1	2	3	18	44	62	20	6	13
	2	5	10–0	44.3	8–11	89	0	0	0	122	778	900	166	296	462	3	6	9	9	9	18	74	56	130	99	100	99
	3	4	11–0	87.0	11–4	103	0	1	1	142	42	184	196	424	620	1	0	1	1	0	1	50	44	94	66	73	70
	4	6	11–11	128.0	14–4	120	0	0	0	80	328	408	338	466	804	4	2	6	8	2	10	8	8	16	–6	17	5
	5	6	11–4	146.6	17–3	152	0	0	0	42	74	116	16	10	26	0	0	0	1	0	1	4	66	70	3	10	7
	6	6	11–9	128.2	14–4	122	0	0	0	100	148	248	272	590	862	1	2	3	0	1	1	14	94	108	38	48	43
	7	5	11–5	108.5	12–9	111	0	0	0	202	296	498	238	434	672	1	2	3	3	3	6	10	26	36	54	45	49
	8	6	11–4	86.7	11–4	100	1	0	1	166	164	330	163	424	588	3	5	8	4	8	12	36	56	92	51	67	59
	9	6	11–8	129.8	14–6	124	0	1	1	26	24	50	96	16	112	0	2	2	2	3	5	22	14	36	50	52	51
	10	5	11–6	103.1	12–4	107	0	0	0	122	364	486	92	196	288	0	1	1	1	2	3	56	82	138	43	74	59
	11	5	11–5	74.5	10–6	92	0	0	0	528	274	802	272	122	394	0	3	3	3	2	5	12	40	52	55	81	68
	12	5	11–7	96.4	11–11	103	0	0	0	32	302	334	262	368	630	0	1	1	1	5	6	132	92	224	44	93	68
	13	4	11–1	66.2	10–0	90	0	0	0	308	148	456	116	114	230	2	3	5	1	2	3	162	62	224	28	69	49
	14	5	11–0	54.5	9–5	85	0	0	0	174	62	236	56	210	266	0	1	1	1	2	3	62	48	110	77	71	74
	15	5	11–7	131.9	14–11	128	0	2	2	56	278	334	180	196	376	0	1	1	1	4	5	10	18	28	52	62	57
	16	5	11–10	109.1	12–9	107	1	0	1	250	638	888	40	196	236	2	1	3	5	7	12	18	136	154	64	96	80
Mean:			11–5		13–5	117	.71	.69	1.40	140.3	212.8	353.1	135.8	233.6	369.4	1.19	1.47	2.66	1.76	2.5	4.26	36.28		81.52		51.02	
																							45.23		44.85		47.92

TABLE VI: SCORES OF THIRTY-SIX ELEVEN-YEAR-OLD BOYS, GROUP A_2, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	B	Total	Character Preference 2. A	B	Total	Reading Preference 3. A	B	Total	Activity Preference 4. A	B	Total	Controlled Association 5. A	B	Total	Offense Rating 6. A	B	Total	Over-statement 7. A	B	Average
1.	1	5	11–6	93.0	11–8	101	0	0	0	130	152	282	60	184	244	2	3	5	1	4	5	28	80	108	55	47	51
	2	6	11–7	143.0	17–2	148	1	2	3	106	8	114	182	50	232	0	0	0	2	4	6	8	20	28	2	34	18
	3	6	11–10	149.7	17–3	145	1	0	1	46	52	98	358	538	896	0	0	0	0	1	1	16	30	46	34	38	36
	4	5	11–8	88.8	11–5	98	1	0	1	100	150	250	92	330	422	1	4	5	5	6	11	74	66	140	61	75	68
	5	5	11–1	115.5	13–4	120	0	1	1	34	130	164	92	144	236	2	3	5	2	5	7	30	54	84	48	–36	6
	6	5	11–7	94.5	11–9	101	1	0	1	242	672	914	140	672	812	3	5	8	3	6	9	132	46	178	60	50	55
	7	4	11–7	100.6	12–2	105	3	0	3	122	148	270	200	520	720	4	5	9	2	6	8	40	64	104	60	96	78
	8	6	11–1	132.7	15–1	156	0	0	0	58	86	144	50	164	214	3	3	6	1	0	1	14	8	22	63	57	60
	9	5	11–8	92.9	11–8	100	4	4	8	166	106	272	64	26	90	1	0	1	2	5	7	70	24	94	53	87	70
2.	1	7	11–11	147.8	17–3	144	0	0	0	52	128	180	116	36	152	0	0	0	1	1	2	10	8	18	11	42	27
	2	6	11–7	118.1	13–7	117	0	0	0	160	62	222	16	152	168	2	0	2	1	1	2	8	27	35	40	33	36
	3	6	11–	110.0	12–10	116	0	0	0	102	128	230	230	418	648	0	1	1	4	7	11	12	26	38	57	36	47
	4		11–	58.2	9–7	87	0	0	0	336	460	796	162	256	418	0	1	1	7	8	15	108	78	186	67	100	83
	5	6	11–	125.9	14–2	128	1	1	2	74	74	148	82	32	114	0	1	1	0	1	1	34	48	82	50	50	50
	6	6	11–5	125.7	14–2	124	0	0	0	144	164	308	96	294	390	0	0	0	0	1	1	2	36	38	50	61	56
	7	7	11–	128.5	14–4	130	0	0	0	156	118	274	162	316	478	0	1	1	0	1	1	34	44	78	55	39	47
	8	6	11–4	113.1	13–2	115	0	0	0	106	204	310	70	180	250	0	0	0	0	0	0	56	36	92	66	57	61
	9	6	10–6	112.0	13–1	124	1	1	2	542	660	1202	346	534	880	4	4	8	8	8	16	10	58	68	79	78	79
	10	7	11–10	126.0	14–3	120	0	0	0	40	8	48	2	46	48	0	0	0	0	0	0	32	22	54	11	25	18
	11	7	11–6	126.5	14–3	124	0	1	1	58	112	170	20	12	32	0	0	0	2	0	2	42	14	56	48	26	37
	12	6	11–0	71.6	10–4	94	0	0	0	130	578	708	242	254	496	2	5	7	0	0	0	92	70	162	75	83	79

3.	1	6	11–6	117.9	13–7	118	9	4	13	58	24	82	340	396	736	0	1	1	1	1	2	18	62	80	65	64	64
	2	6	11–8	114.9	13–4	114	0	0	0	150	62	212	144	10	154	0	0	0	0	1	1	16	34	50	31	5	18
	3	5	12–1	124.1	14–1	116	0	0	0	182	184	366	106	236	342	2	3	5	5	7	12	10	18	28	19	52	36
	4	6	11–11	126.0	14–2	118	3	3	6	66	96	162	68	14	82	0	0	0	2	5	7	16	48	64	74	40	57
	5	6	11–1	101.5	12–3	110	0	1	1	96	426	522	340	370	710	1	1	2	3	1	4	0	22	22	36	49	42
	6	3	11–0	34.2	8–6	77	7	3	10	510	684	1194	214	502	716	3	5	8	8	8	16	156	120	276	95	100	97
	7	5	11–0	116.1	13–5	122	0	0	0	294	380	674	112	302	414	1	1	2	3	2	5	38	62	100	17	80	49
	8	6	11–2	108.0	12–8	113	0	0	0	174	760	934	146	280	426	1	4	5	3	3	6	16	58	74	36	60	48
	9	6	11–5	125.1	14–2	124	1	0	1	106	112	218	82	16	98	0	2	2	4	0	4	30	58	88	33	23	28
	10	5	11–0	73.0	10–4	94	0	0	0	130	26	156	240	536	776	1	1	2	2	6	8	40	40	80	76	94	85
	11	6	11–5	116.7	13–6	117	0	0	0	216	62	278	232	240	472	4	4	8	3	5	8	28	52	80	30	63	46
	12	6	11–11	137.9	16–2	135	0	2	2	78	32	110	142	368	510	0	1	1	0	1	1	8	28	36	50	53	52
	13	5	11–2	98.5	12–0	107	0	0	0	216	24	240	128	172	300	0	0	0	3	4	7	40	38	78	45	77	61
	14	6	11–5	90.3	11–6	101	6	5	11	312	188	500	280	204	484	1	5	6	9	7	16	14	138	152	56	70	63
	15	6	12–1	125.3	14–2	117	0	1	1	420	948	1368	386	592	978	6	6	12	11	12	23	30	46	76	50	81	65
Mean:			11–5		13–3	115	1.08	.8	1.88		223.83		159.5	261	420.5	1.22	1.94	3.16	2.72	3.55	6.27	36.44		83.19		55.27	
										161.44		385.27											46.75		48.83		52.05

TABLE VII: SCORES OF FORTY-ONE ELEVEN-YEAR-OLD BOYS, GROUP B_1, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	1. B	1. Total	Character Preference 2. A	2. B	2. Total	Reading Preference 3. A	3. B	3. Total	Activity Preference 4. A	4. B	4. Total	Controlled Association 5. A	5. B	5. Total	Offense Rating 6. A	6. B	6. Total	Over-statement 7. A	7. B	7. Average
1.	1	5	11–7	64.6	9–11	85	0	0	0	396	490	886	162	616	778	4	5	9	8	8	16	170	126	296	72	81	76
	2	4	11–6	60.0	9–9	84	4	6	10	212	546	758	162	590	752	4	4	8	3	7	10	102	112	214	76	82	79
	3	6	11–7	98.6	12–1	104	2	1	3	182	132	314	144	218	362	0	3	3	4	5	9	80	52	132	88	98	93
	4	7	11–0	159.3	17–3	156	3	0	3	358	378	736	192	120	312	1	2	3	3	4	7	50	62	112	33	35	34
	5	5	11–1	71.1	10–3	93	0	0	0	94	182	276	60	68	128	0	1	1	2	6	8	14	42	56	68	91	80
	6	5	11–7	117.3	13–6	116	0	0	0	118	62	180	102	174	276	0	0	0	1	1	2	66	46	112	39	81	60
	7	6	11–11	107.0	12–7	105	5	4	9	190	286	476	92	104	196	1	2	3	2	5	7	24	82	106	12	16	14
	8	8	11–8	145.3	17–3	148	0	0	0	2	24	26	10	62	72	1	2	3	1	4	5	0	22	22	–7	–66	–37
	9	6	11–6	141.0	16–9	145	0	0	0	94	226	320	50	116	166	1	0	1	0	0	0	44	44	88	60	55	58
	10	6	11–7	143.1	17–3	149	0	0	0	130	770	900	62	26	88	1	0	1	0	2	2	38	82	120	36	33	34
2.	1	5	11–0	99.4	12–1	110	0	0	0	288	128	416	188	128	316	1	4	5	2	5	7	30	34	64	42	37	39
	2	4	11–3	87.3	11–4	101	1	3	4	142	358	500	258	260	518	1	0	1	2	5	7	146	192	338	92	95	94
	3	4	11–	51.7	9–4	85	1	2	3	464	306	770	224	374	598	3	3	6	6	5	11	164	140	304	100	97	99
	4	6	11–9	148.3	17–3	147	0	0	0	96	62	158	56	72	128	0	1	1	0	1	1	68	26	94	54	14	34
	5	5	11–4	95.2	11–10	104	2	0	2	16	40	56	150	76	226	1	0	1	0	1	1	40	8	48	74	26	50
	6	7	11–8	150.0	17–3	148	0	0	0	142	94	236	154	160	314	0	1	1	0	0	0	8	46	54	–3	–33	–18
	7	5	11–6	96.3	11–11	104	7	1	8	42	604	646	200	268	468	2	4	6	3	6	9	18	34	52	83	84	84
	8	5	11–0	41.8	8–9	80	8	9	17	246	446	692	82	474	556	4	4	8	8	10	18	108	74	182	63	46	54
3.	1	7	10–11	109.0	12–9	116	5	2	7	390	534	924	208	272	480	1	1	2	2	3	5	28	72	100	63	100	81
	2	7	11–9	138.0	16–2	137	0	0	0	62	134	196	20	18	38	0	1	1	1	0	1	12	54	66	–3	19	8

	3	6	11–5	77.1	10–7	92	0	0	0	98	292	390	248	266	514	0	1	1	1	2	3	82	98	180	86	98	92
	4	5	11–6	106.2	12–6	108	3	1	4	196	122	318	58	78	136	1	1	2	2	4	6	76	64	140	56	45	51
	5	5	11–0	74.5	10–5	95	2	0	2	138	172	310	106	54	160	1	2	3	4	7	11	152	70	222	88	98	93
	6	5	11–11	68.4	10–2	85	0	0	0	130	148	278	72	294	366	3	2	5	1	3	4	56	55	111	55	93	74
	7	5	11–0	90.8	11–7	105	1	0	1	142	42	184	90	28	118	1	0	1	1	5	6	8	20	28	63	67	65
	8	6	11–3	78.3	10–8	95	0	1	1	80	78	158	238	114	352	1	0	1	2	5	7	100	16	116	80	66	73
	9	5	11–0	99.2	12–1	110	0	0	0	130	166	296	88	32	120	2	0	2	1	2	3	44	44	88	84	48	66
	10	6	11–11	104.5	12–6	105	0	0	0	122	130	252	22	106	128	1	0	1	0	0	0	30	74	104	43	54	48
	11		11–2	109.4	12–9	114	1	1	2	10	352	362	34	18	52	0	0	0	0	0	0	32	40	72	54	71	62
4.	1	5	9–11	60.1	9–9	98	0	0	0	58	64	122	62	234	296	1	0	1	2	2	4	68	116	184	61	44	53
	2	5	11–2	117.5	13–7	121	0	0	0	224	314	538	82	46	128	2	3	5	4	7	11	46	50	96	60	0	30
	3	6	11–6	143.4	17–3	150	0	0	0	162	110	272	22	100	122	1	0	1	0	0	0	4	56	60	37	38	37
	4	7	11–10	129.7	14–6	122	0	2	2	142	58	200	254	24	278	0	3	3	6	5	11	6	24	30	35	72	54
	5	6	11–6	97.7	12–	104	0	0	0	112	184	296	46	10	56	1	2	3	1	4	5	22	28	50	85	100	92
	6	4	11–8	70.0	10–3	88	0	0	0	54	240	294	206	494	700	4	5	9	8	8	16	14	66	80	19	24	22
	7	5	11–1	47.1	9–1	82	0	0	0	70	486	556	368	424	792	1	0	1	6	4	10	64	106	170	100	67	83
	8	6	11–4	71.4	10–3	91	2	2	4	130	482	612	42	282	324	1	2	3	3	2	5	136	102	238	84	54	69
	9	6	11–4	153.3	17–3	152	0	0	0	150	146	296	58	332	390	1	1	2	0	1	1	36	18	54	18–	33	7
5.	1	7	11–0	114.4	13–3	120	0	0	0	294	348	642	16	156	172	1	2	3	2	1	3	12	46	58	43	26	35
	2	6	11–9	144.0	17–3	146	0	0	0	106	78	184	162	52	214	0	1	1	0	4	4	44	64	108	83	50	66
	3	4	11–1	44.1	8–11	80	0	0	0	154	200	354	264	540	804	3	3	6	7	7	14	42	98	140	98	96	97
Mean:			11–4		12–9	112	1.14	1.09	2.0	157.7	244.2	401.9	124.7	192.2	316.9	1.26	1.61	2.87	2.44	3.68	6.09	55.7	63.5	119.2	57.0	54.5	55.7

TABLE VIII: SCORES OF THIRTY-SIX ELEVEN-YEAR-OLD BOYS, GROUP B_2, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	1. B	1. Total	Character Preference 2. A	2. B	2. Total	Reading Preference 3. A	3. B	3. Total	Activity Preference 4. A	4. B	4. Total	Controlled Association 5. A	5. B	5. Total	Offense Rating 6. A	6. B	6. Total	Over-statement 7. A	7. B	7. Average
1.	1	7	11–11	128.6	14–5	121	1	0	1	10	78	88	32	28	60	0	0	0	0	1	1	92	98	190	27	32	30
	2	3	11–5	73.3	10–4	90	0	0	0	136	318	454	150	258	408	1	1	2	0	1	1	68	34	102	54	83	68
	3	4	11–1	25.8	8–6	76	2	2	4	114	964	1078	223	328	551	4	5	9	12	9	21	164	110	274	100	95	98
	4	6	11–8	120.8	13–10	118	3	6	9	92	708	800	226	516	742	3	4	7	5	8	13	48	40	88	89	84	86
	5	6	11–9	137.	15–10	134	4	3	7	262	476	738	218	510	728	0	2	2	2	6	8	46	50	96	58	94	76
	6	6	11–5	140.3	16–7	145	9	6	15	98	26	124	46	12	58	1	1	2	0	2	2	10	22	32	67	70	69
	7	6	11–10	122.7	14–	118	0	1	1	246	530	776	80	162	242	1	3	4	2	3	5	6	8	14	44	96	70
	8	5	11–4	61.6	9–9	86	9	8	17	224	356	580	172	226	398	3	5	8	10	8	18	110	124	234	93	100	96
	9	7	12–0	106.9	12–7	105	9	5	14	42	368	410	112	328	440	0	1	1	0	2	2	28	104	132	67	86	77
2.	1	4	11–8	71.3	10–3	88	0	0	0	78	536	614	216	492	708	2	4	6	6	8	14	100	102	202	76	93	84
	2	5	11–4	56.1	9–6	84	3	3	6	308	502	810	68	326	394	3	4	7	4	9	13	184	170	354	100	91	96
	3	6	11–9	69.2	10–2	86	0	1	1	144	92	206	72	16	88	1	0	1	3	6	9	46	58	104	58	70	64
	4	5	11–9	86.6	11–4	97	0	0	0	474	922	1396	212	552	764	4	5	9	8	11	19	96	38	134	85	41	65
	5	6	11–7	42.4	8–10	76	1	0	1	440	496	936	76	244	320	5	2	7	9	8	17	172	190	362	100	100	100
	6	4	11–4	77.5	10–8	94	0	2	2	232	62	294	166	268	434	3	3	6	5	8	13	104	84	188	88	92	90
3.	1	5	11–2	72.7	10–4	92	0	1	1	178	378	556	42	86	128	4	5	9	3	4	7	118	74	192	83	100	91
	2	6	12–2	85.4	11–2	91	0	0	0	150	310	460	230	246	476	2	2	4	0	2	2	52	94	146	65	50	58
	3	5	11–	61.4	9–9	88	1	0	1	360	254	614	166	136	302	2	2	4	5	8	13	56	86	142	75	73	74
	4	5	11–	58.5	9–8	88	0	0	0	48	276	324	26	142	168	0	0	0	1	3	4	56	50	106	38	80	59
	5	7	12–	83.7	11–1	92	1	0	1	58	486	544	94	120	214	1	0	1	0	1	1	46	32	78	38	70	54

	6	6	12–	82.8	11–	92	0	1	1	184	26	210	144	150	294	1	3	4	1	0	1	84	118	202	16	71	43
	7	6	12–1	86.7	11–4	94	0	0	0	222	518	740	142	410	552	3	3	6	5	7	12	4	34	38	91	82	87
	8	6	11–9	106.7	12–7	107	0	0	0	322	182	504	146	254	400	1	1	2	0	4	4	26	30	56	13	56	34
4.	1	7	11–5	127.7	14–4	125	0	2	2	8	412	420	234	440	674	0	4	4	1	4	5	10	14	24	47	51	49
	2	5	11–6	127.5	14–4	124	0	0	0	410	1144	1554	274	620	894	5	6	11	8	7	15	14	34	48	62	80	71
	3	5	11–4	92.0	11–8	103	0	0	0	312	536	848	116	280	396	1	3	4	1	2	3	80	96	176	80	50	65
	4	4	11–3	35.9	8–7	76	0	0	0	352	718	1070	142	326	468	1	4	5	4	8	12	176	118	294	100	93	97
	5	5	11–1	97.5	12–	108	0	0	0	88	118	206	22	12	34	1	0	1	2	5	7	118	68	186	47	57	52
	6	5	11–1	67.0	10–1	91	7	9	16	86	234	320	118	114	232	1	0	1	2	1	3	40	20	60	50	86	68
	7	6	11–7	101.5	12–3	106	4	6	10	194	642	836	188	520	708	4	4	8	8	9	17	24	68	92	76	69	72
	8	5	11–1	126.6	14–3	128	0	0	0	40	78	118	128	140	268	0	1	1	1	2	3	90	74	164	15	50	33
	9	4	11–	50.7	9–3	84	1	0	1	188	184	372	206	458	664	3	2	5	10	6	16	96	152	248	67	23	45
	10	4	11–	41.3	9–10	80	2	1	3	292	630	922	138	282	420	2	4	6	6	6	12	67	68	135	83	93	88
	11	7	11–8	161.2	17–3	148	0	0	0	122	58	180	138	278	416	1	3	4	6	3	9	18	40	58	42	19	30
5.	1	4	11–1	94.6	11–10	107	1	1	2	246	712	958	108	544	652	6	4	10	6	9	15	42	78	120	58	7	33
	2	6	11–8	108.8	12–9	109	3	0	3	130	96	226	52	122	174	1	1	2	2	1	3	28	24	52	55	33	44
Mean:			11–6		11–8	101	1.69	1.61	3.3	191	401	591	137	276	413	1.97	2.55	4.55	3.83	5.05	8.88	70.0	72.3	142.3	64.	70.	67

TABLE IX: SCORES OF FIFTY TWELVE-, THIRTEEN-, AND FOURTEEN-YEAR-OLD BOYS, SPECIAL SCHOOL GROUP, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

							1. Books Read			2. Character Preference			3. Reading Preference			4. Activity Preference			5. Controlled Association			6. Offense Rating			7. Over-statement		
School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Total	A	B	Average
1.	1	4	12–6		9–11	80	0	0	0	236	532	768	248	458	706	4	1	5	6	10	16	100	88	188	100	0	50
	2	5	12–11		12–6	96	0	0	0	484	418	902	188	596	784	2	3	5	12	4	16	16	28	44	70	68	69
	3	5	12–5		12–3	98	10	10	20	324	476	800	298	218	516	4	5	9	1	2	3	36	64	100	80	81	80
	4	6	13–7				4	1	5	48	122	170	68	18	86	1	0	1	1	5	6	22	28	50	67	76	72
	5	6	13–1		12–5	95	2	0	2	166	274	440	172	150	322	1	0	1	6	7	13	20	48	68	60	100	80
	6	4	13–7		8–5	62	5	0	5	238	920	1158	136	540	676	5	2	7	10	8	18	37	50	87	100	100	100
	7	5	13–11		11–0	80	2	0	2	68	298	366	334	352	686	3	2	5	2	2	4	36	24	60	76	100	88
	8	6	13–0				2	2	4	396	704	1100	278	330	608	2	0	2	5	3	8	84	40	124	88	100	94
	9	5	13–4				1	0	1	122	570	692	78	224	302	0	1	1	3	5	8	42	46	88	76	100	88
	10	7	13–7		14–9	109	3	4	7	224	94	318	142	220	362	1	1	2	4	3	7	8	16	24	–5	58	26
	11	7	13–9		11–2	81	5	2	7	136	26	162	104	84	188	0	0	0	3	8	11	10	120	130	84	100	92
2.	1	6	14–6		11–8	78	7	4	11	82	212	294	260	580	840	5	3	8	9	10	19	76	22	98	89	100	94
	2	7	14–10				2	4	6	18	242	260	218	528	746	5	4	9	8	12	20	22	76	98	75	65	70
	3	8	14–2				0	2	2	158	786	944	280	498	778	3	3	6	1	5	6	14	42	56	19	61	40
	4		14–11				3	5	8	70	642	712	134	632	766	5	4	9	7	9	16	18	16	34	100	87	93
	5	8	14–5		14–1	97	4	4	8	422	368	790	282	496	778	4	2	6	6	8	14	48	20	68	26	55	40
	6	6	14–0				1	0	1	114	470	584	110	42	152	3	3	6	5	6	11	35	42	77	87	88	88
	7	5	14–5		12–9	88	5	5	10	416	908	1324	386	692	1078	5	5	10	9	9	18	30	60	90	65	85	75
	8	7	14–8		13–10	87	0	0	0	106	168	274	98	192	290	1	3	4	4	2	6	8	4	12	71	58	64
	9	8	14–0		15–2	106	3	5	8	284	360	644	40	192	232	3	4	7	7	6	13	12	52	64	45	31	38
	10	9	14–10		13–9	92	10	10	20	130	660	790	220	470	690	4	3	7	1	7	8	10	12	22	93	81	87

	11	9	14–6	12–11	89	8	10	18	334	420	754	130	294	424	3	2	5	3	3	6	4	20	24	59	74	66
	12	6	14–2			2	5	7	150	148	298	44	56	100	1	1	2	1	2	3	110	54	164	87	100	94
	13	9	14–9	16–4	110	3	3	6	146	152	298	18	136	154	0	2	2	1	0	1	16	16	32	68	38	53
	14	6	14–7			2	3	5	196	262	458	304	214	518	2	0	2	8	9	17	10	80	90	31	85	58
	15	6	14–10	11–0	79	2	4	6	236	652	888	174	436	610	2	1	3	5	7	12	86	62	148	85	100	92
	16		14–6	11–1	76	2	2	4	274	754	1028	186	302	488	2	1	3	6	7	13	62	98	160	100	100	100
3.	1		12–0	11–2	93	0	1	1	90	680	770	194	518	712	1	4	5	8	6	14	92	92	184	84	91	88
	2	6	12–0	15–11	132	0	0	0	268	616	884	426	602	1028	4	6	10	2	5	7	24	64	88	32	84	58
	3	4	12–1	10–3	85	2	0	2	220	418	638	160	362	522	2	5	7	10	8	18	106	88	194	76	74	75
	4	7	13–5	14–1	105	8	0	8	328	62	390	28	12	40	1	1	2	8	7	15	170	148	318	82	88	85
	5		13–4	12–0	90	0	0	0	192	676	868	140	274	414	1	1	2	7	8	15	168	176	344	95	100	97
	6	7	13–13	12–1	91	9	0	9	136	596	732	274	498	772	1	3	4	5	5	10	124	88	212	–21	54	17
	7	7	13–2	12–3	101	2	2	4	138	132	270	246	584	830	0	1	1	4	6	10	32	88	120	62	86	74
	8		13–10	14–8	106	0	0	0	130	116	246	120	34	154	2	2	4	1	4	5	146	18	164	67	67	67
	9		13–10	17–0	123	2	0	2	54	222	276	52	58	110	2	1	3	2	2	4	92	32	124	26	18	32
4.	1	9	14–10	14–7	98	5	3	8	88	122	210	280	440	720	1	1	2	2	3	5	2	32	34	42	30	36
	2	7	14–5	15–2	105	5	4	9	134	42	176	72	110	182	1	4	5	4	3	7	52	56	108	46	42	44
	3	6	14–6	11–8	80	7	7	14	80	312	392	100	266	366	5	6	11	8	6	14	72	52	124	67	100	83
	4	4	14–5	12–2	84	0	0	0	166	386	552	200	120	320	1	2	3	6	7	13	41	57	98	91	100	95
	5	7	14–11	11–11	80	0	0	0	202	148	350	36	6	42	2	0	2	2	2	4	72	98	170	70	88	79
	6	8	14–2	10–11	77	0	1	1	472	382	854	316	192	508	2	0	2	3	4	7	34	38	72	68	90	79
	7	8	14–11	14–6	97	0	0	0	96	192	288	64	104	168	1	0	1	4	4	8	38	44	82	43	84	63
	8		14–4	12–11	90	4	3	7	82	100	182	82	58	140	1	2	3	1	2	3	0	2	2	72	84	78
	9	7	14–1	12–11	92	0	2	2	200	42	242	68	240	308	1	0	1	1	0	1	154	144	298	52	100	76
	10	7	14–7	13–9	94	0	0	0	158	332	490	112	328	440	4	4	8	4	6	10	36	68	104	39	66	52
	11	7	14–11	12–8	85	1	0	1	182	732	914	304	362	666	4	4	8	6	5	11	24	54	78	71	73	72
	12	7	15–0	15–2	101	0	0	0	94	188	282	192	550	742	2	3	5	4	2	6	24	80	104	–15	22	3
	13	8	14–0	17–3	125	0	0	0	146	74	220	88	332	420	3	2	5	4	0	4	16	58	74	22	25	24
	14	8	14–7	13–7	93	1	0	1	48	8	56	292	492	784	2	1	3	4	4	8	10	20	30	78	69	73
Mean:			14–0	13–0	93	2.68	2.16	4.84	185.6	364.2	549.8	175.5	309.8	485.3	2.3	2.18	4.5	4.68	5.16	9.64	50.0	56.5	106.5	62.9	74.5	68.7

TABLE X: SCORES OF THIRTY-SIX THIRTEEN- AND FOURTEEN-YEAR-OLD BOYS, WHITTIER STATE SCHOOL GROUP, ON NATIONAL INTELLIGENCE TESTS AND ON CHARACTER-BEHAVIOR BLANKS

School No.	Pupil No.	Grade	Age	N.I.T.	M.A.	I.Q.	Books Read 1. A	B	Total	Character Preference 2. A	B	Total	Reading Preference 3. A	B	Total	Activity Preference 4. A	B	Total	Controlled Association 5. A	B	Total	Offense Rating 6. A	B	Total	Over-statement 7. A	B	Average
1.	1	6	13–8		11–7	85	2	7	9	50	8	58	78	14	92	1	0	1	0	0	0	12	6	18	55	60	57
	2	6	13–7		11–1	82	0	1	1	66	342	408	106	32	138	1	0	1	2	2	4	32	58	90	51	56	54
	3	7	13–7		14–0	103	0	0	0	150	208	358	26	16	42	0	0	0	2	3	5	112	48	160	47	86	67
	4	6	13–9		12–1	88	5	7	12	32	346	378	312	554	866	3	4	7	0	3	3	16	14	30	33	56	45
	5	7	13–1		12–3	94	0	1	1	34	40	74	64	42	106	1	0	1	1	1	2	16	32	48	45	42	43
	6	6	13–4		12–6	94	4	6	10	194	26	220	180	264	444	2	3	5	2	0	2	12	14	26	68	78	74
	7	5	13–9		10–10	79	1	0	1	210	228	438	162	142	304	3	2	5	10	9	19	66	44	110	43	60	52
	8	5	13–1		10–2	78	2	5	7	228	468	696	302	620	922	5	4	9	5	5	10	40	154	194	82	94	88
	9	5	13–6		11–4	84	8	5	13	198	750	948	202	252	454	5	5	10	10	7	17	40	92	132	75	70	72
	10	5	13–9		11–3	82	2	6	8	50	188	238	158	430	588	1	3	4	1	0	1	28	36	64	70	89	80
2.	1	8	14–9		14–6	98	0	0	0	94	40	134	142	40	182	2	4	6	3	2	5	16	32	48	39	43	41
	2	7	14–5		12–3	85	9	1	10	32	26	58	16	20	36	1	0	1	0	1	1	8	14	22	67	72	70
	3	7	14–8		12–4	84	6	2	8	50	160	210	118	14	132	1	0	1	1	2	3	10	16	26	60	63	61
	4	7	14–11		14–2	95	2	1	3	30	86	116	18	34	52	0	0	0	0	0	0	6	8	14	44	27	36
	5	6	14–1		12–1	86	1	3	4	94	446	540	41	12	53	0	2	2	1	1	2	10	20	30	58	92	75
	6	8	14–7		14–4	98	5	5	10	118	26	144	12	46	58	1	1	2	0	1	1	24	38	62	56	76	66
	7	6	14–7		11–4	78	10	10	20	200	606	806	208	46	254	2	2	4	4	5	9	62	34	96	50	13	31
	8	8	14–8		14–10	101	0	0	0	250	1098	1348	272	530	802	5	5	10	8	6	14	14	22	36	68	56	62
	9	7	14–11		13–2	88	0	0	0	90	74	164	46	90	136	1	1	2	1	3	4	90	82	172	19	19	19
	10	7	14–2		14–5	102	7	8	15	204	326	530	124	292	416	3	2	5	0	1	1	28	24	52	57	83	70
	11	7	14–7		13–7	93	0	1	1	162	76	238	306	198	504	1	1	2	1	1	2	6	32	38	59	53	56

12	7	14–10	13–4	90	1	1	2	2	26	28	68	36	104	0	0	0	1	1	2	4	16	20	64	56	60
13	8	14–9	12–1	82	5	6	11	90	74	164	20	22	42	1	0	1	2	4	6	32	14	46	63	91	77
14	7	14–8	12–2	82	9	6	15	262	330	592	28	20	48	5	4	9	1	2	3	20	26	46	60	67	64
15	8	14–11	13–0	87	0	1	1	34	62	96	16	6	22	0	0	0	0	2	2	4	4	8	74	34	54
16	6	14–9	12–9	86	2	3	5	54	458	512	220	300	520	3	2	5	3	3	6	62	32	94	67	91	79
17	8	14–10	15–0	101	0	0	0	32	368	400	250	50	300	2	1	3	4	2	6	8	12	20	25	0	12
18	8	14–10	12–2	82	0	0	0	42	62	104	50	8	58	0	0	0	0	2	2	10	50	60	35	77	56
19	5	14–10	11–5	77	1	3	4	114	224	338	56	68	124	1	1	2	2	5	7	6	32	38	78	80	79
20	5	14–4	11–0	77	4	4	8	42	78	120	90	90	180	0	1	1	0	2	2	26	42	68	52	56	54
21	8	14–4	11–9	82	0	1	1	84	78	162	304	266	570	2	2	4	1	1	2	2	18	20	66	92	79
22	6	14–1	11–8	83	6	8	14	328	476	804	276	238	514	4	3	7	9	6	15	48	20	68	65	67	66
23	9	14–6	15–0	103	0	1	1	174	74	248	34	152	186	1	2	3	1	1	2	52	54	106	20	23	21
24	5	14–2	11–11	84	7	2	9	142	550	692	82	368	450	2	2	4	1	2	3	14	18	32	35	41	38
25		14–5	14–7	101	4	4	8	34	32	66	90	8	98	0	1	1	1	1	2	22	30	52	52	68	60
26		14–11	11–6	77	1	2	3	154	0	154	446	714	1160	4	5	9	4	3	7	10	6	16	25	28	27
Mean:		14–4	12–7	88	2.89	3.08	5.97	114.6	235.0	349.6	136.7	167.7	304.4	1.77	1.75	3.52	2.27	2.50	4.78	27.14		60.56		59.97	56.7
																					33.42		53.53		

CHAPTER VI

STATISTICAL EVALUATION OF RESULTS

No apology need be made for resorting to statistical methods in connection with the evaluation and interpretation of the test results reported in the previous chapter, where such methods aim at an evaluation of the reliability of the measures used, and the nature of the unreliability of the results. There is the danger of looking on the test scores merely as mathematical expressions, without any reference to their meaning in the test situation. There is, however, another danger equally serious, viz., that of describing and interpreting the results on the basis of purely personal observation and analysis, and in terms of subjective measures and criteria. In the methods of statistical evaluation resorted to in the present study, an attempt was made to avoid both these extremes. An effort was made to use such methods as would merit subscription to Webb's statement: "For the given data, and under the given conditions the following statements are true. You are bound either to believe them, or having collected similar data under similar conditions to substantiate your disbelief."

The object of the experiment may be repeated here: It was to find out whether the distinctions of social and moral adjustment, which are known to exist between different groups of boys, can be detected in a test situation.

In the treatment of the results an attempt was made to answer the following questions: (1) How reliable are the tests, and to what extent are the tests measuring the same functions? (2) What is the nature of the distinction found between the test scores of the different groups of subjects on all the different tests? (3) What is the nature of the distinction found between the test scores of the different groups of subjects, when the individual's responses on the different tests are combined into a single measure? (4) What is the relation between the scores of the group

on a character-behavior test and their scores on an intelligence test? (5) What is the general nature of the distribution of the test scores of the different groups?

1. *Reliability and Interrelationship of Tests.*

The coefficients of the reliability of the different tests are given in Table XI. These were calculated from the subjects of the thirteen-year-old B groups, as they were considered to approximate an average group more closely. The coefficients for character preference and reading preference are the same as those reported in connection with the preliminary experiment (Chapter IV).

TABLE XI

Reliability Coefficients for Different Tests

Test	I. Books Read	.59	—by Brown's formula—	.74
Test	II. Character Preference	.66		.79
Test	III. Reading Preference	.67		.80
Test	IV. Activity Preference (½ against ½)	.59		.74
Test	V. Controlled Association (½ against ½)	.63		.77
Test	VI. Offense Rating	.64		.78
Test	VII. Overstatement	.76		.86
Test	VIII. National Intelligence Test	.85		

These reliabilities are markedly satisfactory when it is borne in mind that the lowest, .74, has a standard error of .06. All the test responses were therefore considered sufficiently reliable to merit further analysis.

It must be noted again (see Chapter IV—Preliminary Experiment) that the form in which Test II was organized in this final experiment did not prove to be as satisfactory as the idea of separate cards, which was used in the preliminary experiment. The subjects knew what they had to do when they came to Form B of the test. The situation was therefore different from that in the case of Form A. This was in part also true of Test III, Reading Preference, although it involved less reading matter, and, therefore, the subjects were less liable to make an offhand selection. Because of this difference of relation to the task in the case of Test II, it was decided to use only the responses to Form

A of the test for further evaluation. The situation in connection with Form A was genuine and unbiased.

In order to find out to what extent the tests measured the same functions the intercorrelations between the different tests were calculated. Table XII gives these intercorrelations, also when they are corrected for attenuation, and the probable errors for the corrected coefficients. The corrections were calculated from *Spearman's formula for attenuation:*

$$r_{\infty\,\infty} = \frac{r12}{\sqrt{r1\,I}\quad\sqrt{r2\,II}}$$

where: $r12$ = the correlation between two dif. measures;
$r1\,I$ = the reliability coefficient of first measure;
$r2\,II$ = the reliability coefficient of the second.

TABLE XII

Intercorrelations, Intercorrelations Corrected for Attenuation, and Probable Errors of the Corrected Coefficients

		N.I.T.	Books Read	Char. Pref.	Read. Pref.	Act. Pref.	Con. Assoc.	Off. Rtng.	Over-St'm't
N.I.T.	r		.2197	.2158	.3824	.4944	.5802	.6277	.6411
	Cor. r		.2774	.2632	.4644	.6242	.7177	.7729	.7505
Books	r	.2197		.1449	.3002	.0957	.1900	.2525	.3641
Read	Cor. r	.2774		.1886	.3892	.1290	.2509	.3319	.4550
P.E. of	Cor. r			.176	.120	.136	.130	.125	.108
Char.	r	.2158	.1449		.6242	.3967	.3526	.0963	.3321
Pref.	Cor. r	.2632	.1886		.7817	.5165	.4498	.1223	.4009
P.E. of	Cor. r		.176		.076	.111	.113	.129	.110
Read.	r	.3824	.3002	.6242		.3603	.4116	.2694	.4989
Pref.	Cor. r	.4644	.3892	.7817		.4671	.5228	.3406	.5999
P.E. of	Cor. r		.120	.076		.113	.107	.119	.093
Act.	r	.4944	.0957	.3967	.3603		.5602	.2277	.3934
Pref.	Cor. r	.6242	.1290	.5165	.4671		.7397	.2993	.4916
P.E. of	Cor. r		.136	.111	.113		.089	.172	.107
Control	r	.5802	.1900	.3526	.4116	.5602		.4907	.3759
Assoc.	Cor. r	.7177	.2509	.4498	.5228	.7397		.6320	.4602
P.E. of	Cor. r		.130	.113	.107	.089		.098	.107
Offense	r	.6277	.2525	.0963	.2694	.2277	.4907		.5027
Rating	Cor. r	.7729	.3319	.1223	.3406	.2993	.6320		.6127
P.E. of	Cor. r		.125	.129	.119	.172	.098		.093
Overstate-	r	.6411	.3641	.3321	.4989	.3934	.3759	.5027	
ment	Cor. r	.7505	.4550	.4009	.5999	.4916	.4602	.6127	
P.E. of	Cor. r		.108	.110	.093	.107	.107	.093	

The probable error for a correlation coefficient corrected for attenuation was calculated from Kelley's [1] formula:

$$\text{P.E.}_{r\infty\infty} = \frac{.6745 r\infty\infty}{\sqrt{N}} \left(r^2\infty\infty + \frac{1}{r^2_{12}} + \left(\frac{1}{4r^2_{1\,I}} - \frac{r^2_{1\,I}}{4}\right) + r_{12} - \frac{1}{r_{1\,I}} - 1\right) + \left(\frac{1}{4r^2_{2\,II}} - \frac{r^2_{2II}}{4} + r_{2\,II} - \frac{1}{r_{2II}} - 1\right)\Bigg)^{\frac{1}{2}}$$

Where: $r12$ = coefficient of correlation between two measures;

$r\infty\infty$ = that coefficient of correlation corrected for attenuation;

$r1\,I$ = reliability coefficient of first measure;

$r2\,II$ = reliability coefficient of second measure;

N = the number of cases.

An examination of Table XII shows: (a) That all the tests are related to one another in a positive manner, that is, they are all, to a more or less degree, measuring the same functions; (b) no single test dominates the whole test situation; each test makes its own positive contribution. Controlled association and overstatement correlate the highest with each of the other tests, but they correlate with each other to the extent of .4602; (c) the correlations of books read with the remaining tests are the lowest, and in some cases insignificant, *e.g.,* with character preference .1886, P.E. .176, with activity preference .1290, P.E. .136. Books read has greater agreement in what it measures with overstatement; this, no doubt, is due to the fact that both tests are measuring forms of exaggeration.

It may, however, be asked: Is this positive relationship, that obtains between the different test measures, not merely due to the factor of intelligence? Does not the subject in every test situa-

[1] KELLEY, T. L. *Statistical Methods,* p. 200, Macmillan.

tion react in a purely rational manner, and in that way cause the relationship between the different test measures to develop? The answer to this question may be found in Table XIII. This table shows to what extent the interrelationship between the tests still exists after the factor of intelligence has been eliminated. This was done for the corrected coefficients of Table XII. The standard errors for the numerators of three of these partials have also been calculated by means of Kelley's (unpublished) formula (given at the foot of Table XIII). The three partials chosen are representative samples, because of their size, and because of the fact that they are connected with at least six of the tests. The significance of the remaining partials can be estimated from these samples.

It appears, that whatever relationship may exist between books read, offense rating, and the remaining tests, is entirely due to the common factor of intelligence entering into the

TABLE XIII

Coefficients of Correlation Between Different Tests, with Intelligence Factor Partialed Out

(Partials were calculated from coefficients corrected for attenuation)

	Books Read	Char. Pref.	Read. Pref.	Act. Pref.	Contr. Assoc.	Offense Rating	Over-St'm't
Books Read		.1198	.3061	—.0589	.0774	.1927	.3887
Char. Pref.	.1198		.7719	.4673	.3884	—.0132	.3191
Read. Pref.	.3061	.7719		.2561	.3072	—.0325	.4397
Act. Pref.	—.0589	.4673	.2561		.5361	—.3699	.0451
Contr. Assoc.	.0774	.3884	.3072	.5361		.1750	—.1704
Offense Rating	.1927	—.0132	—.0325	—.3699	.1750		.0777
Overstatement	.3887	.3191	.4397	.0451	—.1704	.0777	

Standard Error for Numerator of

^{r}Bks. read—Ch. pref. (i.e., .1156) is .122
^{r}Rd. pref.—Overstate. (i.e., .2514) is .091
^{r}Act. pref.—Con. Asc. (i.e., .2917) is .091

Kelley's Formula:

For finding the standard error of a partial correlation derived from intercorrelations that have been corrected for attenuation. Where $k^2 = (1 - r^2_{12})$, etc.; and s = the factor that has been partialed out; f = numerator of partial calculated from coefficient corrected for attenuation:

$$\text{S. D.}_{f} = \frac{1}{N}\left\{ r^2_{12} + r^2_{sS} + r^2_{1s} + r^2_{2s} + 2r^2_{1s}\,r^2_{2s} - 4r_{12}\,r_{1s}\,r_{2s} - 2r_{sS}\,(r^2_{1s} + r^2_{2s}) + 2r_{12}\,r_{1s}\,r_{2s}\,r_{sS} - f^2(k^2_{12} + k^2_{sS} + k^2_{1s} + k^2_{2s} - r^2_{1s} - r^2_{2s}).\right.$$

responses. (Books read, overstatement, and reading preference are the only exceptions.) This seems to be what might be expected, especially in the matter of rating offenses; the task, in the main, is one of abstract judgment.

The relationship between the remaining tests is well sustained, except in the case of overstatement with controlled association, and with activity preference. But controlled association and activity preference still correlate to the extent of .5361.

Hence the answer to question one, stated above, can be stated thus: The different tests developed for and used in connection with this experiment are reliable to a fair degree; they are positively related in what they measure, while no single test dominates the influence of the rest; the interrelationship which two of them (books read and offense rating) have with the others is almost entirely due to the extent to which intelligence functions in all the test responses.

2. *The Nature of the Distinctions Found Between Test Scores.*

Now that the character of the tests has been determined, it becomes possible to turn to the actual test scores in order to examine what they have to reveal concerning the different groups of subjects.

It might be of service to recall that the original subjects were selected from different communities with different social and educational opportunities.

A_1—most stable, etc.—in a privileged community.
A_2—least stable, etc.—in a privileged community.
B_1—most stable, etc.—in a less privileged community.
B_2—least stable, etc.—in a less privileged community.
Special —Parental School Group.
Whittier —Whittier State School.

Because of the fact that Whittier School subjects were somewhat older than those in the other groups, and because the Special School subjects were the most *natural* types of delinquents, it was decided to take this latter group as the one to be contrasted with the others.

Table XIV gives the mean scores and standard deviations for all the groups on all the different tests.

In making a comparison between the scores of the more stable groups and those of the less stable groups, *e.g.*, between A_1 and A_2, B_1 and B_2, etc., it must be remembered that these divisions are not as absolute or extreme as might be thought at first. These subjects were, indeed, selected on the basis of their constituting the 25 per cent most stable and the 25 per cent least stable boys of a certain age in a certain grade. This does not necessarily mean that there were very wide differences between, say, two boys that were selected from one grade. It very frequently happened that the teacher had difficulty in deciding who should be placed at either extreme. The differences did not loom large in the judgment of the teacher.

Then, too, it must be remembered that these subjects were selected from different grades, 4 to 8, by different teachers, and from different schools. Under such circumstances it is only natural that any wide division between the ultimate groups is not a possibility. It is, however, equally impossible to get enough subjects at the extremes in one and the same school—not even to speak of the same grade.

Table XIV shows very marked differences between the mean scores of some groups. (A low score is desirable, or better; a high score is undesirable, or worse.) There is always a very significant difference between the most stable groups and the special group. This is not always the case when the comparison is made with the Whittier Group. No doubt maturity and the helpful influences of direction and guidance at a school of the type of Whittier have been instrumental in creating new and better interests. It is interesting to note the larger scores with the eleven-year-olds in comparison with the thirteen-year-olds. The distinction between the B_1 and B_2 groups seems to be more marked than that between the A_1 and A_2 groups. It is no doubt due to the fact that the conditions under which the B groups are brought up afford the greater opportunity for differentiation. The child

TABLE XIV: MEAN SCORES AND STANDARD DEVIATIONS FOR ALL AGES AND GROUPS ON BEHAVIOR BLANKS

13 yr. Group	No.	Books Read Mean	Books Read SD	Char. Pref. Mean	Char. Pref. SD	Reading Pref. Mean	Reading Pref. SD	Act. Pref. Mean	Act. Pref. SD	Contr. Assoc. Mean	Contr. Assoc. SD	Off. Rating Mean	Off. Rating SD	Overstatement Mean	Overstatement SD
A 1.	50	1.84	3.4	135.5	108.1	250.3	215.8	1.84	1.9	3.5	4.5	72.5	56.3	43.5	19.7
A 2.	37	3.05	4.2	137.3	79.7	311.5	277.8	2.32	2.05	2.9	2.6	75.3	74.5	46.6	20.4
B 1.	43	2.6	3.0	118.3	74.7	234.4	170.9	1.90	1.4	3.1	3.1	78.8	54.8	50.3	21.5
B 2.	40	2.9	4.4	170.8	107.2	393.7	262.8	3.45	2.82	5.6	5.0	84.5	61.9	55.1	21.8
Special School Group	50	4.8	5.1	185.6	112.5	485.3	273.0	4.50	2.8	9.6	5.1	106.5	72.64	68.7	23.9
Whittier State Sch. Group	36	6.0	4.7	114.0	50.8	304.4	287.0	3.52	3.08	4.78	4.7	60.6	45.9	56.7	18.7
11 yr. Group															
A 1.	42	1.40	3.3	140.3	110.5	369.4	270.0	2.7	2.6	4.3	4.5	81.5	48.3	47.9	25.8
A 2.	36	1.88	3.3	161.4	123.8	420.5	268.5	3.2	3.3	6.3	5.6	83.2	53.8	52.1	20.7
B 1.	41	2.0	3.3	157.7	104.7	316.9	216.7	2.9	2.4	6.1	4.7	119.2	75.21	55.7	26.0
B 2.	36	3.3	4.9	190.6	122.1	413.0	225.0	4.6	3.0	8.9	6.1	142.3	87.4	67.0	21.1

is left more to himself; he is less guarded; he comes more in contact with the conditions that generate delinquency.

Table XV expresses the significance of the differences discussed above very clearly. The difference between the mean scores of two groups is expressed as the multiple of its standard deviation. The standard deviation of the difference was calculated from the formula:

$$\text{S.D. of diff.} = \sqrt{\frac{\text{S.D.}_1}{N_1} + \frac{\text{S.D.}_2}{N_2}}$$

Where: S.D._1 = standard deviation of the mean score of the first group.

S.D._2 = standard deviation of the mean score of the second group.

N_1, N_2 = the respective number of cases.

It is interesting to note how different tests are more instrumental in bringing out significant differences between groups than others, *e.g.*, the differences on reading preference, activity preference, and controlled association are more marked than in the case of the other tests. Offense rating is the poorest in differentiating between the groups. All of them fail to find any significant differences between the eleven-year-olds A_1 and A_2.

Another method of evaluating the differences between the test responses of the groups is to note the extent to which the differentiation thus made between the groups corresponds with the original differentiation made by the teachers. This was done by means of calculating the "bi-serial coefficient of correlation"[1] between groups. The formula for this is:[2]

$$r = \frac{(M_1 - M_2)\ pq}{\text{S.D.}\ z}$$

[1] KELLEY, T. L. *Statistical Method*, p. 249. Macmillan.

[2] (For explanation of symbols, see foot of Table XV, following.)

TABLE XV

Showing the Significance of the Difference Between the Means of the Various Groups on All the Tests

Test	Age	Better	Worse	Difference Between Means	Standard Deviat. of Dif.	Difference Expressed as Multiple of Its Stand. Dev.
Books Read	13 yrs.	A_1	A_2	1.21	.841	1.44
		A_1	Spcl.	2.96	.867	3.41
		B_1	B_2	.30	.833	0.36
		B_1	Spcl.	2.2	.854	2.57
	11 yrs.	A_1	A_2	.48	.749	0.64
		A_1	Spcl.	3.40	0.883	3.85
		B_1	B_2	1.3	.966	1.35
		B_1	Spcl.	2.8	.886	3.16
Char. Pref.	13 yrs.	A_1	A_2	1.80	20.134	0.09
		A_1	Spcl.	50.1	22.063	2.27
		B_1	B_2	52.5	20.423	2.57
		B_1	Spcl.	67.3	19.568	3.44
	11 yrs.	A_1	A_2	21.1	26.766	0.79
		A_1	Spcl.	45.3	23.311	1.94
		B_1	B_2	32.9	26.106	1.26
		B_1	Spcl.	27.9	22.814	1.22
Reading Pref.	13 yrs.	A_1	A_2	61.2	54.948	1.11
		A_1	Spcl.	235.0	49.214	4.77
		B_1	B_2	159.3	49.049	3.25
		B_1	Spcl.	250.9	46.581	5.38
	11 yrs.	A_1	A_2	51.1	61.141	0.84
		A_1	Spcl.	115.9	59.565	1.95
		B_1	B_2	96.1	50.507	1.90
		B_1	Spcl.	168.4	57.576	2.92
Activ. Pref.	13 yrs.	A_1	A_2	.48	.431	1.11
		A_1	Spcl.	2.66	.479	5.55
		B_1	B_2	1.55	.495	3.13
		B_1	Spcl.	2.60	.451	5.76
	11 yrs.	A_1	A_2	.5	.680	0.74
		A_1	Spcl.	1.8	.564	3.19
		B_1	B_2	1.7	.624	2.72
		B_1	Spcl.	1.6	.545	2.94
Contr. Assoc.	13 yrs.	A_2	A_1	.6	.767	0.78
		A_1	Spcl.	6.1	.962	6.34
		B_1	B_2	2.5	.921	2.71
		B_1	Spcl.	6.5	.862	7.54
	11 yrs.	A_1	A_2	2.0	1.163	1.72
		A_1	Spcl.	3.3	1.001	3.30
		B_1	B_2	2.8	1.254	2.23
		B_1	Spcl.	3.5	1.028	3.40

Test	Age	Better	Worse	Difference Between Means	Standard Deviat. of Dif.	Difference Expressed as Multiple of Its Stand. Dev.
Offense Rating	13 yrs.	A_1	A_2	2.8	14.610	0.19
		A_1	Spcl.	34.0	12.992	2.62
		B_1	B_2	5.7	12.868	0.44
		B_1	Spcl.	27.7	13.239	2.09
	11 yrs.	A_1	A_2	1.7	11.658	0.15
		A_1	Spcl.	25.0	12.686	1.97
		B_1	B_2	23.1	18.414	1.25
		Spcl.	B_1	12.7	15.249	0.83
Overstatement	13 yrs.	A_1	A_2	3.1	4.359	0.71
		A_1	Spcl.	25.2	4.380	5.75
		B_1	B_2	4.8	4.757	1.01
		B_1	Spcl.	18.4	4.708	3.91
	11 yrs.	A_1	A_2	4.2	5.268	0.80
		A_1	Spcl.	20.8	5.222	3.98
		B_1	B_2	11.3	5.371	2.10
		B_1	Spcl.	13.0	5.283	2.46

Explanation of symbols for the formula for "bi-serial coefficient of correlation":

M_1 and M_2 = means of the test scores of the two groups.
p = proportion of cases in one group.
q = proportion of cases in the other.
S.D. = standard deviation in the test scores of the two groups combined.
z = ordinate of the normal probability curve at the point where the proportion of cases on one side of it is p.

Table XVI gives a summary of the bi-serial coefficients of correlation for the different groups on all the tests. Practically the same points of difference are noted here. There is fair agreement in the differences made between groups B_1 and B_2 but little agreement concerning those of A_1 and A_2. The difference between the special group and the various other groups correlates highly with the differentiation made between the groups by the standards of educational practice—they are in reality segregated from the regular school groups. It might be noted again that offense rating and books read are least in agreement with the differentiation made by the teachers.

TABLE XVI

Bi-Serial Coefficients of Correlation and Combined Standard Deviations for the Different Groups and Ages

	Books Read	Char. Pref.	Read. Pref.	Act. Pref.	Con. Assoc.	Off. Rtng.	Over-st'm'nt.
13 Years							
A_1 and A_2							
Bi-serial r	.14	.09	.13	.13	—.08	.02	.08
S.D.	4.3	99.4	244.1	1.8	3.8	66.25	20.0
A_1 and Special							
Bi-serial r	.41	.28	.54	.61	.67	.31	.63
S.D.	4.6	113.2	272.8	2.75	5.74	69.0	25.2
B_1 and B_2							
Bi-serial r	.07	.33	.404	.41	.352	.06	.12
S.D.	3.74	99.7	246.7	2.34	4.45	59.9	25.8
B_1 and Special							
Bi-serial r	.312	.41	.60	.61	.73	.26	.47
S.D.	4.41	102.8	263.4	2.65	5.54	67.09	24.4
11 Years							
A_1 and A_2							
Bi-serial r	.09	.11	.12	.11	.24	.02	.11
S.D.	3.3	119.0	267.7	2.96	5.28	51.07	23.6
A_1 and Special							
Bi-serial r	.45	.25	.26	.39	.59	.24	.48
S.D.	4.7	115.3	277.8	2.89	5.6	63.91	27.01
B_1 and B_2							
Bi-serial r	.19	.18	.27	.37	.31	.18	.29
S.D.	4.3	113.5	224.7	2.86	5.58	82.5	24.3
B_1 and Special							
Bi-serial r	.37	.16	.40	.36	.41	—.11	.32
S.D.	4.69	107.0	262.1	2.79	5.28	74.4	25.4

3. *Nature of Distinction Between Groups on Test Series as a Whole.*

In order to make a comparison between the groups on a basis of scores on the test series as a whole, the different tests had to be duly weighted, so that each test should contribute its proper share to the total score. The weight that each original test score should get was calculated from the formula:

$$W = \frac{1}{\text{S.D.}} \cdot \frac{\text{(aver. r with criterion)}}{\text{(aver. intercorrelation)}}$$

(The average r with criterion was the bi-serial r for the thirteen-year-old B groups; the other factors were also taken for those groups.) The following are the weights calculated:

Test	I	Books Read	16
Test	II	Character Preference	2
Test	III	Reading Preference	1
Test	IV	Activity Preference	100
Test	V	Controlled Association	40
Test	VI	Offense Rating	0.5
Test	VII	Overstatement	2

TABLE XVII: COMBINED TOTAL SCORES ON WHOLE TEST BATTERY FOR ALL GROUPS AND AGES AFTER WEIGHTING SEPARATE TESTS

13 yrs. A_1		13 yrs. A_2		13 yrs. B_1		13 yrs. B_2		11 yrs. A_1		11 yrs. A_2		11 yrs. B_1		11 yrs. B_2		Special		Whittier	
N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.	N.	Sc.
School 1		School 1		School 1		School 1		School 1		School 1		School 1		School 1		School 1		13 years	
1	167	1	46	1	191	1	237	1	172	1	136	1	141	1	29	1	251	1	56
2	108	2	256	2	117	2	67	2	40	2	68	2	280	2	111	2	305	2	70
School 2		3	278	3	62	3	223	3	118	3	114	3	169	3	292	3	271	3	76
1	42	School 2		4	56	4	122	4	151	4	178	4	178	4	251	4	77	4	205
2	69	1	118	5	45	5	242	5	115	5	115	5	92	5	208	5	150	5	48
3	171	2	197	6	40	6	257	6	50	6	267	6	77	6	93	6	289	6	173
4	39	3	101	7	25	7	134	7	166	7	110	7	138	7	150	7	172	7	216
5	60	4	105	School 2		School 2		8	27	8	112	8	66	8	295	9	223	8	306
6	60	5	81	1	224	1	286	9	260	School 2		9	61	9	115	9	110	9	297
7	201	6	51	2	113	2	236	10	52	1	40	10	66	School 2		10	147	10	145
8	41	7	312	3	40	3	53	School 2		2	86	School 2		1	329	11	126		
9	73	8	114	4	51	4	92	1	25	3	150	1	178	2	269	12	298	14 years	
10	65	School 3		5	38	5	106	2	167	4	205	2	160	3	97	13	277	1	128
11	131	1	75	6	86	6	51	3	340	5	58	3	296	4	357	14	207	2	55
12	26	2	95	7	74	7	91	4	37	6	85	4	57	5	298	15	279	3	72
School 3		School 4		School 3		8	157	5	138	7	106	5	55	6	232	16	303	4	24
1	204	1	71	1	241	9	294	6	25	8	63	6	76	School 3		17	165	5	75
2	125	2	122	2	121	School 3		7	207	9	363	7	183	1	196	18	399	6	86
3	93	3	133	3	218	1	110	8	161	10	19	8	304	2	144	19	128	7	184
4	65	4	62	4	123	2	218	9	98	11	35	School 3		3	218	20	226	8	300
5	117	5	66	5	150	3	189	10	94	12	169	1	198	4	60	21	245	9	80
6	222	6	158	6	86	4	62	11	148	School 3		2	35	5	63	22	226	10	177
School 4		7	71	7	164	5	256	12	28	1	141	3	120	6	130	23	110	11	125
1	26	8	194	8	73	6	314	13	76	2	56	4	120	7	227	24	90	12	35
2	43	9	93	9	107	7	139	14	175	3	177	5	151	8	150	25	203	13	91
3	87	10	33	10	76	8	146	15	74	4	74	6	149	School 4		26	222	14	198
4	32	11	27	11	46	9	153	16	40	5	137	7	90	1	143	27	220	15	30
5	57	12	142	12	133	10	123	School 3		6	367	8	111	2	358	School 2		16	165
6	38	13	59	13	99	11	45	1	77	7	155	9	88	3	176	1	226	17	94
7	38	14	78	School 4		School 4		2	259	8	165	10	62	4	249	2	300	18	36

8	20	15	87	1	67	1	129	3	125	9	79	11	26	5	79	2	262	18	107
9	38	16	122	2	111	2	367	4	198	10	177	School 4		6	105	4	195	20	71
10	75	17	88	3	56	3	47	5	20	11	216	1	87	7	293	5	196	21	140
11	158	18	33	4	107	4	283	6	154	12		2	162	8	72	6	213	22	286
12	23	19	111	5	189	5	101	7	173	96		3	66	9	231	7	188	23	103
13	321	20	103	6	43	6	83	8	238	13	117	4	146	10	238	8	123	24	150
14	223	21	78	7	72	7	120	9	70	14	275	5	99	11	151	9	82	25	62
15	65	22	65	8	120	8	200	10	94	15	412	6	243	School 5		10	151	26	276
16	25	23	235	8	75	School 5		11	211			7	168	1	290	11	152		
17	129	24	66	10	105	1	173	12	128			8	140	2	92	12	264		
18	91			11	115	2	42	13	168			9	97			13	171		
19	89			School 5		3	55	14	103			School 5				14	105		
20	205			1	35	4	194	15	95			1	128			15	214		
21	202			2	23	5	31	16	177			2	87			16	95		
22	33			3	71							3	254			17	89		
23	182			4	222											18	118		
24	147			5	149											19	211		
25	98															20	248		
26	74															21	173		
27	137															22	146		
28	136															23	168		
29	77																		
30	40																		
Population:																			
50		37		43		42		42		36		41		36		50		36	
Mean:																			
	99.8		111.5		101.3		155.7		124.1		142.2		136.7		185.8		196.4		131.7

TABLE XVIII

Bi-Serial Coefficients of Correlation, Standard Errors for Bi-Serial r's, and Combined S.D.'s for All Groups on Test Series as a Whole

	Bi-serial r	Standard Error of Bi-serial r	Combined S.D.
13 years:			
A_1 and A_2	.11	.13	68.09
A_1 and Spcl.	.72	.07	83.96
B_1 and B_2	.44	.12	78.12
B_1 and Spcl.	.74	.07	80.85
11 years:			
A_1 and A_2	.14	.14	85.59
A_1 and Spcl.	.55	.099	82.63
B_1 and B_2	.36	.13	84.64
B_1 and Spcl.	.47	.11	78.76

The final scores reported in Table XVII are the totals found, divided by ten. The significance of the means for different groups on the test as a whole is indicated in Table XIX. All the differences are significant excepting in the case of the thirteen-year-olds and the eleven-year-olds A_1 and A_2. In Table XVIII the bi-serial coefficients of correlation are given for the different groups on the test series as a whole. Here, again, all the coefficients are significant but for those between A_1 and A_2 thirteen-year-olds and A_1 and A_2 eleven-year-olds.

TABLE XIX

Showing the Significance of the Differences of the Means for All Groups on Test Series as a Whole

Better	Worse	Difference Between Means	S.D. of Difference	Diff. Expressed as Multiple of Its Stand. Dev.
13 years:				
A_1	A_2	11	14.69	.75
A_1	Spcl.	96	14.73	6.52
B_1	B_2	55	17.66	3.11
B_1	Spcl.	95	15.75	6.03
11 years:				
A_1	A_2	25	18.56	1.35
A_1	Spcl.	72	15.78	4.56
B_1	B_2	49	18.86	2.56
B_1	Spcl.	59	16.38	3.60

4. *Relation Between Scores on Character-Behavior Tests and Scores on Intelligence Test.*

The question of influence of intelligence on the relationship that obtains between the test responses has already been discussed in Section 1 of this chapter. One additional factor, however, has still to be noted. In Table XX the correlations between the mental ages and the scores on the test series as a whole are given. The mental ages of the thirteen-year-olds are somewhat influenced by the fact that the test did not extend far enough for the older groups, and there consequently resulted an error of grouping. This handicap, though, affected all the thirteen-year-old groups.

If the correlations are examined it will be noted that, but for the thirteen-year-old A_2 Group, all the correlations are positive, and that there is a constant relationship between the groups, viz., the A_1 and B_1 groups (the stable groups) have consistently higher correlations than the A_2 and B_2 groups (the unstable groups). It would hence appear that the boys who are known and judged to be stable, reliable, etc., have used their intelligent understanding in facing moral and social problems; their intelligence is a very potent factor in maintaining those qualities.

When, however, a boy gets steeped in delinquent interests and practices, he does not go that way because of his lack of intelligence, but rather in spite of his intelligence. Other factors, environmental and physiological no doubt, have been greater determinants in his development. The influence of these latter factors are particularly marked in the case of the special group.

TABLE XX

Correlation Between Mental Ages and Scores on Test Series as a Whole: Standard Errors of Correlation, Means and Standard Deviations for M.A., and Scores for All Groups and Ages

	13 years				11 years				Special
	A_1	A_2	B_1	B_2	A_1	A_2	B_1	B_2	
Correlation M.A. and Test Sc..	.363	−.0488	.392	.323	.852	.385	.586	.285	.211
Standard Error Correlation...	.121	.164	.134	.142	.0424	.144	.103	.153	.147
Mean M.A.....	14–11	14–10	14–6	14–4	13–5	13–3	12–9	11–8	13–0
S.D. M.A.....	26.7	28.8	29.8	29.2	30.1	23.0	34.0	25.7	23.0
Mean Test Score	100	111	101	156	124	149	137	186	196
S.D. Test Score.	67.56	67.93	72.60	87.04	71.66	87.3	76.29	87.75	72.84
No. of Cases...	50	37	43	40	42	36	41	36	42

The correlation between their test responses and mental ages is only .211. If the lack of intelligence were in the main responsible for delinquent development the correlation between the lower mental ages and the higher scores (that is, badness) of the special group ought to have been much higher. For the same reason the correlation between the mental age and the score on the behavior tests for the A_1 and B_1 groups ought then to have been higher than those for the A_2 and B_2 groups. (It must be borne in mind that high scores on the behavior tests indicate extremely undesirable interests.)

When the findings of this section are viewed in the light of those of sections 2 and 3, there seem to be sufficient grounds to conclude that the differences that are brought out between the groups by means of these tests are differences of appreciation of moral and social values rather than differences of ability to reason and to judge in the abstract.

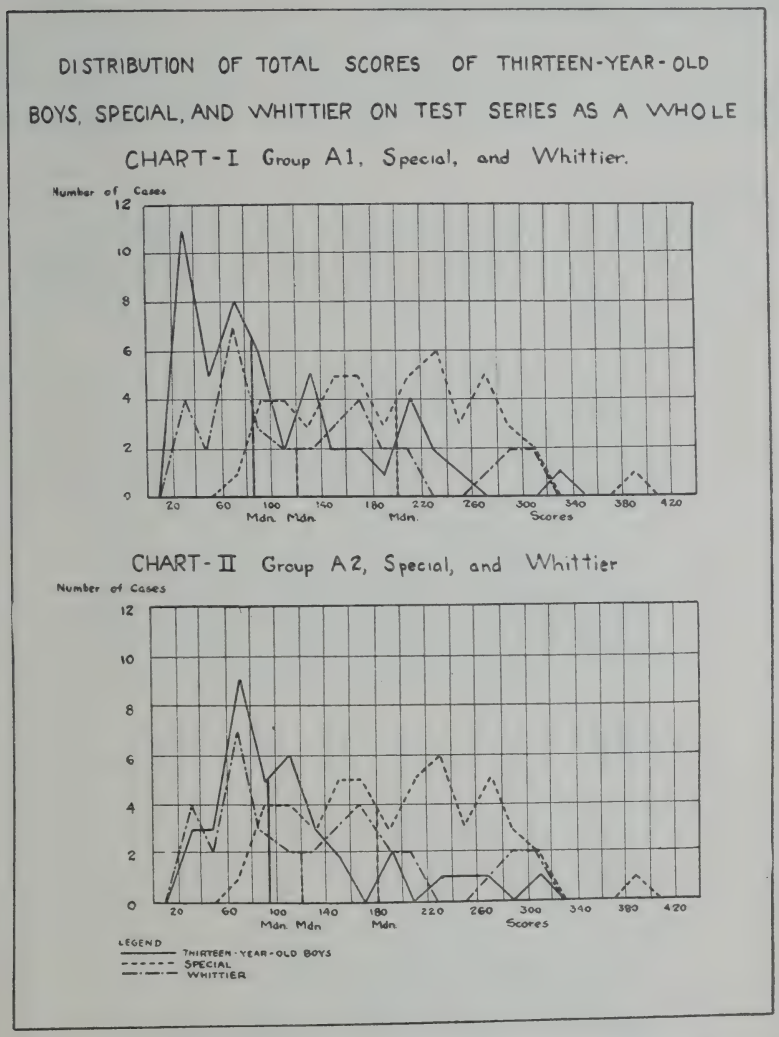
TABLE XXI

Distribution of Total Scores of All Ages and Groups on the Test Series as a Whole, Together with the Median Scores for Each Group

	13 Years				11 Years					
Score	A_1	A_2	B_1	B_2	A_1	A_2	B_1	B_2	Special	Whittier
20– 40	11	3	5	1	6	2	2	1		4
40– 60	5	3	7	6	4	2	2	1		2
60– 80	8	9	8	2	4	4	7	3	1	7
80–100	6	5	3	3	5	3	7	3	4	3
100–120	2	6	7	3	3	6	1	3	4	2
120–140	5	3	4	6	3	2	4	1	3	2
140–160	2	2	2	3	3	3	4	5	5	3
160–180	2		1	1	7	5	6	1	5	4
180–200	1	2	2	2	1	1	2	1	3	2
200–220	4		1	3	2	2		2	5	2
220–240	2	1	2	3	1			5	6	
240–260	1	1	1	2	2	1	2	2	3	
260–280		1				2		1	5	1
280–300				3			2	5	3	2
300–320		1		1			1		2	2
320–340	1									
340–360					1		1	2		
360–380				1		2				
380–400									1	
400–420						1				
Number of Cases	50	37	43	41	42	36	41	36	50	36
Median Score	83	92	90	138	113	130	127	180	200	120

5. *Distribution of Test Scores of Groups.*

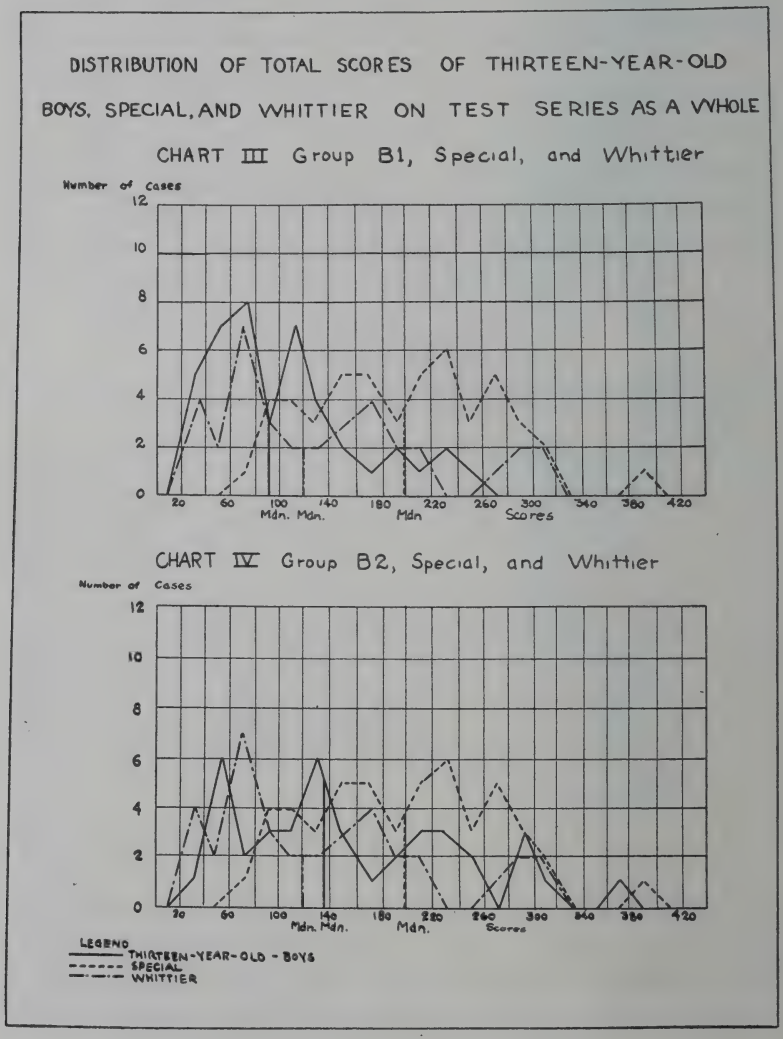
Table XXI and Charts I–VIII explain the nature of the distribution of the test scores of the different groups. The median scores



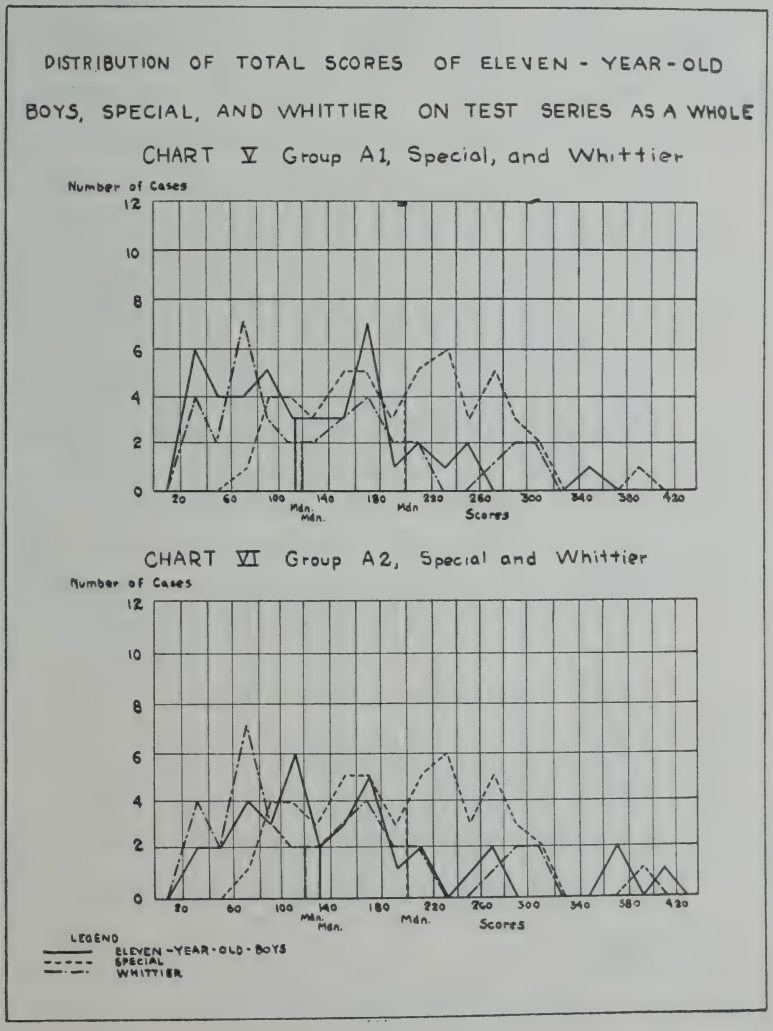
of the A_2 and B_2 groups are consistently higher (worse) than those of the A_1 and B_1 groups. The special group has a median score markedly higher than all the other groups. The evidence of the influence of environmental conditions and of maturity in the

case of the other groups would point to the conclusion that the relatively lower median score of the Whittier group is, no doubt, due to the more helpful circumstances in which they have been placed at the Whittier State School.

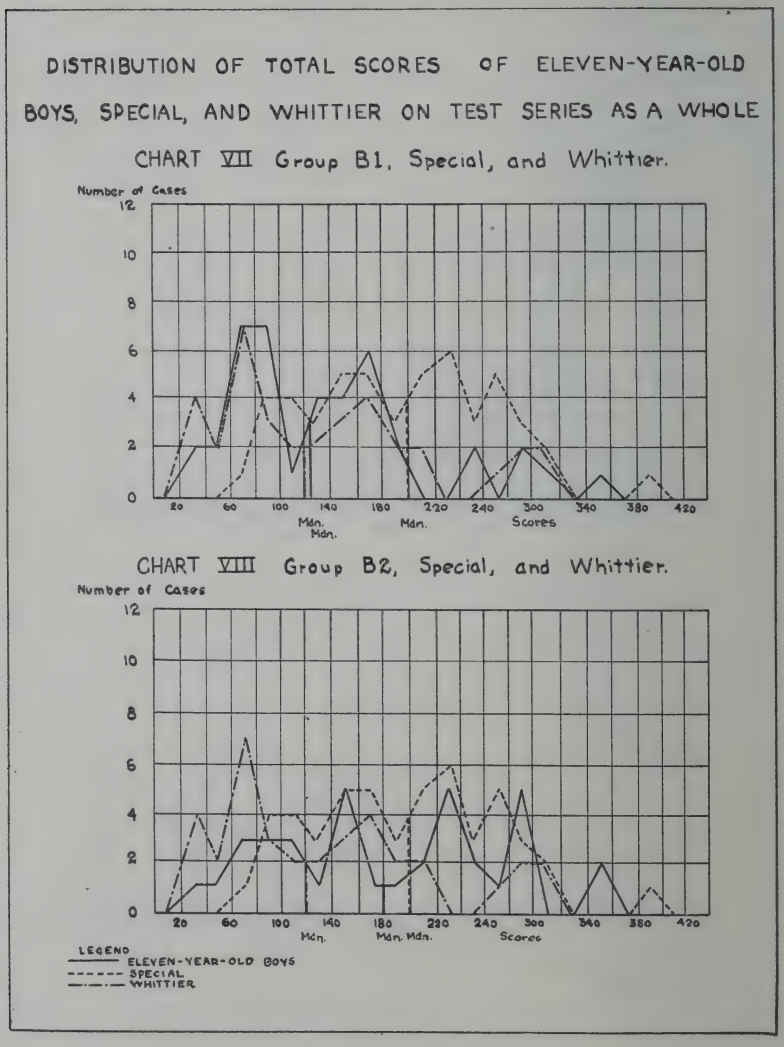
The effect of maturity can be seen very clearly when, say, the unstable groups of the eleven-year-olds, A_2 and B_2, are compared with the unstable thirteen-year-olds. Their scores change from



130 and 180 to 92 and 138, respectively. It would seem that a process of constant differentiation operates from year to year. The greatest number of boys seem to move up in the scale of moral and social adjustment, the nature of their progress depending very much on the educational and social conditions by which they are surrounded. A very much smaller number of boys in the course of their development, no doubt, will approach the



Special School Group. If the charts are compared in their reverse order, beginning with number VIII, a very clear picture can be had of the development of the boys at different ages and under different environmental conditions, from the eleven-year-old B_2 group, that approach the distribution of the Special School Group very closely, to the widely differentiated thirteen-year-old A_1 group.



CHAPTER VII

INDIVIDUAL VALIDATION

As was stated in Chapter I, the primary aim of this study was not so much to develop a method for detailed diagnosis of the individual, as first to make sure that certain groups that are varyingly adjusted socially and morally can be differentiated by means of an objective test method. The extent to which the test method that has been developed can make such a valid differentiation was demonstrated in the last chapter.

It was thought that it might be worth while at this point to inquire into the nature of the individual's responses to the test series. How does the rating of the individual on the behavior tests compare with the rating given him by those who know him? In considering such a comparison, it must be remembered, that there are two grave difficulties in the process: the first is the ever-recurring stumbling block, viz., the question of getting reliable ratings[1] for the subject. The second is one unique to this problem, viz., the ratings are to be made on an increasing scale of *questionable* characteristics and interests. Honesty ranges from absolute honesty to extreme dishonesty. There can be no average dishonest person—he is dishonest for all that. The same is true for all other moral qualities.

In order to meet the first handicap, it was decided to give the whole series of tests to a group of forty boys, ages about twelve with a range of eighteen months, in a private military school in Menlo Park. The boys board at the school; there was every reason to believe that the teachers, who live there too, would know these boys more intimately than teachers in the public schools could know the pupils in their grades.

[1] Rugg, H. O. Is the Rating of Human Character Practicable? *Jour. Ed. Psy.*, 12, 1921, pp. 425–438, 485–501; 13, 1922, 30–42, 81–93.

Three of the teachers were asked to rank the boys on a scale of eleven points for each of the following traits:

I. Overstatement of facts—exaggeration of own qualities, knowledge, experience, reliability of report or statement.
The extremes here were:
1. Extremely exact and dependable regarding statements; knows measure of abilities, etc.
11. Extremely prone to exaggeration; boastful; totally wrong conception of own abilities and knowledge.

II. Attitude towards different "institutions with which the boy comes in contact," *e.g.*, school, teachers, studies, home, scouts, duties, discipline, and the like. Is there evidence of indifference, braggadocio, snobbishness?
The extremes here were:
1. Very, very healthy and wholesome attitude; realizes relative values of factors in his development.
11. Extremely indifferent; defiant; constantly in trouble.

III. Recognition of social, moral and cultural standards of values in the choice of associates, reading, books and pictures, means of spending leisure time, forms of amusement, hobbies.
The extremes here were:
1. Extremely worth while and wholesome selections.
11. Inclined to make selections of an extremely questionable character.

The teachers were asked to place a boy in one of the eleven categories for each of these traits. The points between the extremes were not described or defined. The teachers were told to think of the eleven steps in terms of particular boys of their own selection, and then to rank all forty in terms of their own criteria. Each teacher worked independently of the other two. The separate rankings of the teachers on each trait were ultimately combined into one ranking for each trait.

The combined ranking for trait I was then correlated with the combined scores of the boys on Test I, Books Read, and Test VII,

Overstatement. These two tests were considered to be testing more or less the same trait, viz., exaggeration. The resultant correlation was .50.

The scores on Test II, Character Preference, and Test III, Reading Preference, were then separately correlated with the combined rankings on Trait III, which gave the correlations of .18 and .11 respectively.

The scores on Test V, Controlled Association, and Test IV, Activity Preference, were combined and correlated with the combined rankings on Trait II. The resultant correlation was .39.

In the case of four of the tests, then, there is positive evidence of a decided agreement between the tests scores and the ratings of the teachers. It is interesting to note that there was greatest agreement between test scores and rankings at the lower end (the undesirable end) of the distribution than at the upper (best end—those ranked as less unreliable, etc.). The four cases sought out as the worst by the teachers are also those discovered as such by different tests. Teachers seem to be well informed of the poor qualities of the problem cases; the questionable interests of the apparently well adjusted boy do not come to his notice. This, perhaps, in part, makes it almost impossible to hope for much higher agreement between teachers' ratings and scores on tests that ordinarily reveal the undesirable qualities of a boy's nature.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

1. The study of Juvenile Delinquency has been almost entirely of an historical or biographical nature. The present study was an experimental attempt to find out whether delinquent interests and practices might not be determined in their earlier development.

2. The method followed was that of securing comparable test data through test situations on groups of boys, eleven- and thirteen-year-olds, who were known to differ in the matter of social and moral adjustment.

3. Seven different tests were developed for the purpose of the experiment. The emphasis of the tests was on questions related to the interests, preferences and activities of the boys. The reliability coefficients for the different tests ranged from .74 to .86.

4. Three of the tests were given to about two hundred and fifty boys in a preliminary experiment to find out whether any differentiation was possible on the basis of the test responses.

For the main inquiry the 25 per cent most stable, reliable, healthy-minded, and the 25 per cent least stable, reliable, healthy-minded eleven- and thirteen-year-old boys were selected from two different communities—the one with abundant social and educational opportunities, the other less privileged socially and educationally. Two control groups were selected from the boys in Parental Schools and a State Reformatory for delinquents.

5. In addition to the above-mentioned tests, the groups were all given a group test of mental ability.

6. The tests were also given to a group of forty boys from a private military school; ratings from three teachers on each of the boys were compared with their test scores, in order to find out the validity of the test scores as approximate measures of the delinquent interests and tendencies of the individual boy.

7. Different statistical methods were used for the purpose of analyzing and evaluating the test material.

The following are the conclusions that may be drawn from the study:

1. The nature of the test responses demonstrates that the form and character of the tests served the purpose for which they were developed, viz., that of getting an expression of the questionable interests and tendencies of boys.

2. The test responses furthermore show significant differentiation between the various public school groups with regard to their adjustment morally and socially, and the differentiation thus made is the more significant in its agreement with that made by the teachers, excepting in the case of the thirteen-year-old A_1 and A_2 groups (the groups from the privileged community). The lack of differentiation with these groups is due, perhaps, to the fact that problem cases from this section of the community very seldom go to the public schools; they are placed in private schools.

3. The differences between the scores of the Parental School Group and those of the various public school groups are very marked, but are relative in degree to the maturity and environmental influences of the groups.

4. It has been demonstrated that the differentiation made by some of the tests between individuals of the same group concerning their particular moral and social habits is valid and significant.

5. The groups that are most stable and reliable and healthy-minded have a consistently higher correlation between their mental ages and their test scores than have the correspondingly less stable, reliable, and healthy-minded groups. That seems to show that, while intelligence is a very important factor in bringing about and maintaining desirable adjustments morally and socially, the boy who gets steeped in delinquent interests and practices goes that way in spite of his intelligence. Factors, other than intelligence, seem to function very positively as determinants in the development of delinquency.

6. Judging from the character of the interests and the preferences of the less stable and reliable groups in the public schools, and the manner in which their interests approach those of the Parental School Group, it would seem that one of the main characteristics of the potentially delinquent is his lack of appreciation of moral and social values.

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VOL. XXXIV PSYCHOLOGICAL REVIEW PUBLICATIONS WHOLE NO. 160
NO. 7 1925

Psychological Monographs

EDITED BY

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The Influence of the Factor of Intelligence on the Form of the Learning Curve

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PUBLISHED FOR
The American Psychological Association
By THE PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.
and ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.)
Leipzig (Hospital St., 10); Paris (76, rue de Rennes)

P.R.M.
v. 347

ACKNOWLEDGMENTS

In the course of this investigation the writer has necessarily become deeply indebted to a number of persons. It is a great pleasure to make specific acknowledgment of the invaluable assistance given by Professors Lewis M. Terman and Truman L. Kelley of Stanford University. The completion of the study was made possible through the granting of a University Fellowship for the year 1920–21 and a Research Fellowship for the year 1921–22. Acknowledgment is due the Committee on Graduate Study and to Professor Terman for these awards. Professor William T. Root, Jr., now of the University of Pittsburgh, gave much appreciated aid in the formulation of the experimental procedure. Through the coöperation of Dr. Virgil E. Dickson, Mr. William M. Greenwell, Mr. Charles E. Keyes, and Mr. John R. Sutton, a large number of children in the city schools of Oakland, California, were made available for subjects in the experiments. Mr. Cecil R. Brolyer, of Stanford University, gave valuable assistance in supervising the compilation and treatment of the experimental results. Dr. Arthur S. Otis, of the World Book Company, was kind enough to read and criticize certain parts of the statistical treatment.

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CHAPTER I

Introduction and Statement of the Problem

The present investigation is primarily an attempt to bring under control and measurement certain factors which are operative in producing individual differences during the practice of mental functions. Most experimental studies which have taken cognizance of such individual variations at all have done so in one or both of two principal ways. The first of these problems is that of the quantitative measurement of the amounts of individual variability in the ability to profit by training, and the second is the question whether practice *increases* or *decreases* these differences in the performance of various subjects.

With respect to the first of these two issues it is now common knowledge that relatively great differences in such capacities do exist and the present interest in this question has narrowed down to the statistical expression of these differences in terms of valid objective units. The second question, on the contrary, has not yielded an unambiguous answer and no generalizations of great significance have been forthcoming. Many psychologists have held firmly that practice decreases or levels down those differences, innate or learned, which are present in the initial performances in the formation of new sets of nerve connections. To-day, the opinion tends to the position that these differences are increased by further exercise of the functions involved.

The experimentation which is reported here was planned to attack this problem of the increase or decrease of individual differences under practice in such a way as to control and measure the influence of two factors which are believed to be prominently involved in the behavior and fate of these differences. Specifically stated, the problem is to study: (1) the influence of the type of mental function which is involved in the learning, and (2) the influence of the factor of general intelligence or the general mental level of the subjects used.

In the main, learning studies have involved very small numbers of subjects who were usually adults. For this reason, probably, the question of the possible influence of innate or acquired differences has not ordinarily been raised. There are surprisingly few studies of the learning of children and almost no investigations where the subjects have been carefully classified and measured with reference to the general mental ability of the learners. Conceivably this might prove to be a factor of great significance. As a matter of fact teachers have seemed more aware of the importance of intelligence in learning than have the laboratory investigators.

In the second place there is probably an unwarranted tendency to generalize too largely about *the learning curve* as if *one particular form of a curve* obtained for all types of mental functions. We have, indeed, suggested several general categories of learning types, such as " sensorimotor," " perceptual," " ideational," etc., without raising the question of the possibility of these being found to possess widely divergent characteristics with respect to the form of their learning curves. It is well within the bounds of reason to expect that the intellectual superiority of a gifted individual might not give him as great an advantage over a less gifted individual in his performance in such a relatively simple situation as cancellation of a's or sorting cards as in the mental multiplication of three-place numbers or in a completion exercise. If this be true, it is of little gain to generalize about the course of individual differences under practice without specific reference to the kind of learning involved.

To measure the influence of these two factors, viz., general mental ability and the type of mental function undergoing practice, the selection of the subjects in the present experiment had to be carried out in a definite manner. The chronological age range was kept as small as was practicable under the actual conditions of securing the necessary subjects. At the same time the mental age range was made as great as conveniently possible in order that the extremes of mental ability might be well represented in numbers.

The selection of suitable tests offered considerable difficulty. In order to vary the type of mental processes to be studied, in accordance with the previously discussed requirements, and not make the experimental work prohibitive in amount, it was desirable to select a small number of tests which would, in a sense, sample the whole range of possibilities from "motor" learning on the one hand to the so-called "higher thought processes" on the other. Tests of sensorimotor capacities are fairly numerous, and one, card sorting, which has been used by many investigators (Bergström, Burt, Coover, Brown, *et al.*) was finally selected as representative of its type. As a second test which would involve comparatively little of the motor element and which would call for use of sensational and perceptual processes, a modification of the Healy Civil War Code was adopted. The selection of a third test needed for the study of learning on a highly intellectual level proved to be very difficult. The possibilities included such tests as the analogies, completion exercises, mental multiplication or addition, and a few others. Unfortunately none of these exist in several comparable forms and it is difficult to measure the efficiency of the learning of such materials from day to day. The final choice was that of an abstract mathematical relations test which will be described in greater detail in a later section. No claim is made that the location of these three tests with respect to their psychological characteristics and demands is based upon any more exact knowledge than a considerable amount of traditional agreement in the terminology of the literature of learning. The real intention, as has already been stated, was merely that of sampling a fairly wide range of mental capacities.

CHAPTER II

The Literature of the Problem

The attempt to summarize even the important experimental work that has been done on the general problem of individual differences in learning capacities would not be warranted by the pertinence of much of this literature to present needs. Nevertheless reference must be made to a number of the older studies which have only indirect bearing in order to give the proper historical orientation for certain controversies which must be taken up later. Recently there has grown up something of a literature on the relation of intelligence to learning. This demands somewhat more careful consideration.

For these reasons, the selection of the papers to be reviewed will be restricted to three groups, viz.: (1) Representative older studies of the increase or decrease of individual differences during practice, of the relations existing between initial and final efficiency in learning, and of the course of the behavior of intercorrelations between mental functions under practice; (2) studies of card sorting, substitution, and reasoning abilities in tests similar to those of the present study; and (3) studies of the learning of subjects classified according to general mental ability, or where the learning has been measured with statistical reference to general intelligence.

Obviously only the investigations of the third type are direct in their significance for present purposes. References to the literature will be made in accordance with the foregoing classification.

I. *Investigations of the Effects of Practice on Individual Differences:*

Binet (1899:4) concluded that for several forms of cancellation tests the differences between bright and dull pupils present at the outset tended to disappear with continued practice. He

says: "La différenciation est nette surtout dès la première épreuve; elle diminue et peut même s'effacer aux épreuves subséquentes" (p. 395).

This conclusion was attacked by Spearman and Krüger (1907: 39) on the basis of their results obtained by refiguring data gathered by Oehrn in 1899 on continued adding. They replied to Binet as follows: "Binet hat, wie schon gesagt, die Meinung ausgesprochen, dass derartige Korrelationen nur bei ungewohnten Versuchsbedingungen deutlich hervortreten; mit zunehmender Uebung sollen sie rasch kleiner werden, manchmal sogar verschwinden. Der eine von uns wurde jedoch zu dem entgegengesetzten Schlusse geführt, dass bei genauer Untersuchtsmethode die Uebung . . . die Korrelationen sogar vergrössert" (p. 96).

Burt (1909:7) studied the same problem but discussion of his results, which are not very conclusive, will be reserved until a later section.

From 1908 on, Thorndike and his students have carried out a series of investigations of individual differences in mental capacities. Thorndike's own paper (1908:46) presented the general tenor of all of the conclusions reached in this group of studies when he says, with reference to multiplication of three-place numbers, ". . . the larger individual differences increase with equal training, showing a positive correlation of high initial ability with ability to profit by training" (p. 384). During the five years from 1911 to 1916, Donovan and Thorndike (1913:15), Hahn and Thorndike (1914:18), Starch (1911:41), Kirby (1913:24), and Thorndike himself in several studies (1910:49, 1914:47, 1915:48), brought forward additional evidence that practice in mental operations in arithmetic resulted in increasing the differences present at the outset. In one of these, (1914:47) after reviewing the work of Galton, Cattell, Rice, and his own study of men entering learned professions, he summarizes by saying: "The facts are rather startling. Equalizing practice *seems to increase* differences. The superior man seems to have got his present superiority by his own nature rather than by

superior advantages of the past, since, during a period of equal advantages for all, he increases his lead" (p. 305).

Wells (1912:52) reported that the learning curves of ten different subjects rarely crossed, and that ". . . . a superior performance at the beginning of special practice is not necessarily or even probably attained at the sacrifice of prospects for future improvement" (p. 88).

Hollingworth, (1913:19) from the use of adding, color naming, opposites, discrimination reaction to colors, coördination (3-hole test), and tapping, concluded that the average intercorrelations of the six tests increased from trial to trial, at least up to certain stages. This point was about the twenty-fifth trial for discrimination and the eightieth trial for adding. The average intercorrelations were .065, .280, .320, .390, and .490 for the medians of trial 1, trials 1–5, 20–25, 75–80, and 200–205, respectively. Hollingworth warns against the use of the initial trials as measures of ability and favors trials nearer the limit of efficiency. Cancellation showed a correlation of .665 between initial and final efficiency but opposites yielded but —.088 between the preliminary and 130th trials. The coefficient for adding was .154 under the same conditions. The number of subjects was but thirteen and all were adults. Hollingworth himself has pointed out that cognizance must be taken of the possible effects of changes in the test functions due to habituation during the long practice periods in interpreting his results.

Whitely (1911:54) reported the results of nine adults of varying levels of ability in tests of discrimination of weights, cancellation of A's, sorting, and the pencil maze. Correlations of about .50 between starting ability and gross gain were computed. These results are not in accord with the findings of others and even certain of Whitely's other findings and have been objected to by Thorndike and others.

Chapman (1914:9) found high correlations between initial and final performances in color naming, cancellation, opposites, and multiplication, the coefficients ranging from .59 to .96 in a group of twenty-two male college students.

Jones (1917:23) has held that the results of Wells, Chapman, and Hollingworth are opposed to Thorndike's position. He refers specifically (p. 20) to the fact that the Wells subjects who gained most in addition gained least in cancellation. This raises an issue which will be returned to after our new data have been presented since it is typical of one of the controversial interpretations of experimental results with which the literature of learning abounds.

Strickland, (1918:43) using the Woodworth-Wells color-naming test, adding, tapping, multiplying, and word building, found that "where practice improves performances correlations increase" (p. 399).

A belief in a "general capacity for learning" has been expressed by Pyle (1919:35). Such a capacity is dependent upon the characteristics of the nervous system itself and would operate to cause intercorrelations between separate tests to approach unity if the extraneous factors could be eliminated.

Many apparent inconsistencies are to be noted in the foregoing account, and the conclusions are by no means unambiguous. The variety of mental processes measured, the probable great differences of mental ability among the subjects used, and the variations in the points of view and statistical methods have all contributed to produce these conflicting interpretations. On the whole there seems to be a preponderance of evidence in favor of the view that practice tends to increase those differences present in human beings at the beginning of learning situations, at least for such complex mental functions as the mental solution of arithmetical problems and reasoning abilities in general. For tasks like cancellation and sensory discrimination, the evidence is uncertain and the formulation of definite conclusions is better omitted until our new data have been presented.

II. *Investigations of Card Sorting, Substitution, and Reasoning Abilities:*

Card sorting as a test of mental ability has been used by many investigators for one purpose or another, *e.g.*, by Bergström

(1894:3), Coover and Angell (1907:11), Culler (1912:12), Calfee (1913:8), Kline and Owens (1913:25), Brown (1914:6), Myers (1918:30), Pyle (1919:35), *et al.* Bergström, Culler, Kline and Owens, and Brown were chiefly interested in studying the effects of interference in habit formation. Coover and Angell emphasized the great individual differences in the imagery and other mental processes of the several subjects and in the same subject at different stages in the learning process. However, none of these studies involved card-sorting techniques which resembled at all closely the one used in the present study.

Calfee has reported correlations between the sorting of cards face up and the sorting the same face down (dealing) ranging from .45 to .71. Of card sorting, card dealing, alphabet sorting, and mirror writing, the first mentioned gave the highest correlation with school grades of children.

Myers has stated that "practice does not make the individuals more or less alike" (p. 325). He refers to card sorting.

Substitution tests have been used in a variety of forms by many workers, *e.g.,* Gray (1918:17), Baldwin (1913:2), Starch (1912:42), Lough (1912:27), Munn (1909:29), Pyle (1913:34), Squire (1912:40), Woodworth and Wells (1911:57), Woolley and Fischer (1914:58), Dearborn and Brewer (1918:14), and many others. The last mentioned only used the Healy Civil War Code. Their methods differed so greatly from those of this investigation that comparisons cannot be made even in this case. Dearborn and Brewer's work, although chiefly intended as a university class demonstration, brought forth certain results of interest, viz., ". . . the students tend to hold the same relative rank in the first trials as in the last trials of the practice" (p. 81). Whipple (1915:53) gives a good summary of the literature and norms on substitution tests (pp. 499–515). Weidensall (1916:51) used the Woolley and Fischer substitution test with delinquent women and found a correlation of .48 with estimated intelligence after several practices.

Bonser (1910:5), Ruger (1910:37), Peterson (1920:33), and many others, have worked with tests of reasoning capacities.

None of these resembles at all closely the "Abstract Relations" test of our experiments and hence need not be commented on at length. Bonser presents evidence that the abilities of naming opposites, controlled association, selective judgments, and even literary interpretation are closely related in their psychological nature.

Ruger has carried out an introspective analysis of the puzzle-solving consciousness with trained adult observers.

III. *Studies of Learning in Relation to General Intelligence.*

Dating from the time of Binet there have been perhaps somewhat more than a score of studies which directly or indirectly have involved a certain amount of consideration of the influence of intelligence as a factor in learning. Binet has already been quoted as believing that dull subjects in certain tests (cancellation) reach a final efficiency equal to that of bright ones.

Kuhlmann (1904:26) found that the learning curves of three Mongolian imbeciles and six feebleminded in target throwing and tapping maintained their relative ranks rather closely.

Terman's study (1906:45) of seven "bright" and seven "stupid" boys presents a detailed account of the differences in the capacities of these boys in the higher mental processes, *e.g.*, in puzzle solving, tests of invention, the ball and field test, mathematical problems, language usage, mutilated texts, fables, memory, chess playing, *et al.* The "bright" group proved much superior to the "stupid" in all the mental tests used, there being the least difference in the tests of invention. The subjects maintained their relative ranks with great uniformity.

Burt (1909:7), with a battery of twelve tests (sensory discrimination, tapping, card sorting, mirror writing, spot-pattern, dotting, etc.), tested English school children in considerable numbers and found that eleven of the twelve tests gave a lower correlation with imputed intelligence on the second trial than in the first. The differences are small, however, and probably not very significant.

Abelson (1911:1) failed to verify Burt's results but found on

the contrary definite tendencies for correlations to rise with repetition of the tests. Abelson observes with reference to Burt's tests that: "His easier ones may well have been tests of intellectual power to normal children when first tried, but tending to become mechanical in repetition; in that case the more defective children would no longer be at such a disadvantage. Mentally deficient children, on the other hand, would not readily master a performance sufficiently to make it mechanical but would have to continue to exert their full powers" (p. 305).

Simpson (1912:39) compared a group of "good" and a group of "poor" adults with a wide range of tests from motor control to "selective thinking." His main interest was that of a critique of the Spearman theory of a "general factor" and his results have little bearing here. Simpson does comment on the data published by Oehrn and refigured by Spearman and Krüger to the effect "that increase or decrease would depend upon the kind of a test and the stage of the subjects in the learning process . . ." (p. 81).

Colvin (1915:10), Woodrow (1916–7:55), Ordahl and Ordahl (1915:31), and Murdoch (1918:28) have studied the learning of subjects of the same mental ages but of differing chronological ages. Woodrow used the problem of sorting gun wads on which had been pasted various geometrical designs. The following have been selected from his results (Table III, p. 936 and elsewhere):

Group	N.	Aver. M. A.	Aver. Initial Trials	Aver. Final Trials	Aver. Improvement	Aver. per Cent of Improv.
Feebleminded	20	8–10	121	175	55	49
Normal		9–1	122	176	55	46

All of these studies seem to show that the learning curves of subjects of equal mental ages are strikingly similar regardless of the great difference in actual ages, except that of Murdoch, who found that normal children improved more in educational tests over a period of a year than did feebleminded children of the same mental age. But, as L. S. Hollingworth (1920:21, p. 178) has pointed out, Murdoch did not take into account the fact that

" the children do not remain of equal mental age " over the period of the experiment, due to the more rapid mental growth of the normal group. Woodrow's experiments do not involve this time error since all of the experimental work was done within a space of about two weeks.

There is almost general agreement that, even where the improvement is equal, the learning curves of the feebleminded show greater daily fluctuations and irregularities than do those of normal children of the same mental ages.

Gould and Perrin (1916:16), using a group of adults and a similar group of children as representing two groups of varying intelligence, compared their curves in maze learning. They concluded that intelligence is manifested chiefly in the initial stages of the learning and that the controlling factors in the later parts of the curves are fatigue and motor control. But they also find that the intelligent learners (the adults) make poorer records on the first two trials than do the less intelligent learners (children) and show a steeper initial rise with greater freedom from steeples. One is tempted to raise the issue here, in view of the results, whether the difference between children and adults in such a function is a matter of intelligence alone and whether such other factors as may be involved hold true explanation of these results. Perrin (1919:32), comparing the learning of adults in the analogies and mirror reading tests, found no correlation between the rankings of the subjects in the two tests, the superior subjects being at their best the farther they were away from the physiological limit of improvement in mirror reading, and the nearer they were to their limit in the analogies test. These relations were reversed in the inferior group. One of Perrin's conclusions is of interest here: " In one respect, the demonstrated lack of relationship is significant. It furnishes justification for the conclusion that the similarity between the tests as regards slope, the greater improvement of the inferior subjects, and the reliability of the initial scores as indices of future accomplishment, *is due to the nature of the tests themselves, rather than to the personnel of*

the practicing group" (pp. 59–60, italics mine). The correlations between initial scores and subsequent improvement were:

Mirror reading.....	.85 to .94
Analogies.....	.59 to .89

Perrin sums up his opinions on the relation of intelligence to learning in the further statement that: ". . . intelligence thus becomes defined in terms of immediate, consistent, and uniform adjustment, not in adjustment considered as a capacity for improvement by leaps and bounds" (p. 51).

Wallin (1916:50) practiced large numbers of children on form boards. The average group improved most, the dullest next, and brightest group somewhat less than the dullest.

Strong (1917:44) says: "The slope of the learning curves of school children based on simple arithmetical combinations apparently correlates to a very considerable extent with the general intelligence of the children" (p. 153). Strong does not, however, present objective data in support of this conclusion.

Myers (1918:30) has already been reported as finding no correlation between the intelligence of normal school children and their abilities in card sorting.

Dallenbach (1919:13) divided a group of feebleminded children into "superior," "medium," and "inferior" groups for study with visual apprehension of numerals, letters, words, and geometrical designs and figures. He used also a group of normal children for purposes of comparison. Mental age correlated with standing in visual apprehension as follows:

Before practice.....	$0.70 \pm .056$
After practice.....	$0.63 \pm .094$

He states that: "Individual differences are marked, but they are closely correlated with the mental age" (p. 82).

Johnson (1919:22) studied three groups of five adults each in a target throwing test. The chronological ages of the subjects ranged from about eighteen to twenty-eight years, and the mental ages from about eight to seventeen years. The groups were divided upon the basis of mental age as superior, medium, and

inferior. No correlations are given but it is stated that the superior group had the greatest initial ability as well as the highest final efficiency, the medium and inferior groups following in their respective orders.

Woodrow (1919:56) claims: "What a child can do and how fast he can learn depends upon his mental age" (p. 37–8).

L. S. Hollingworth (1920:21), after reviewing the experimental evidence at some length, supports the contention of Woodrow and others in the following statement: "The feebleminded learn at the same rate, and in the same way as normal children of equal mental age, in tasks in which both have been experimentally tested" (p. 186).

CHAPTER III

Description of the Methods of the Investigation

The Subjects:

In accordance with the experimental aims already recorded, the subjects were selected upon the basis of intelligence or general mental ability. No additional selective agencies are known to have been involved other than those operative on all public school children. Racially the subjects were all of European descent with the exception of one girl who was included in ignorance in advance of the fact that she was partly of negro ancestry.

In all, about 120 different subjects took part in one or more of the experiments. From fifty to sixty-five subjects were used in each experiment. Eleven took part in all three tests. These subjects were pupils in the seventh, eighth, or ninth grades of the University High School, Eugene, Oregon, the Lincoln Elementary School of Oakland, California, or the Oakland High School. The experiments extended over the period from 1919 to 1922.

The chronological ages varied around fourteen years as a mode. The exact ages are recorded in Tables I, II, and III of Chapter IV.[1] Obviously it would have been desirable to have used subjects who were all exactly of the same age but the practical difficulties of securing the requisite numbers at any one age made it necessary to sacrifice to some extent this theoretical advantage and attempt to allow for the influence of the chronological age differences by resorting to the method of partial correlations as an approximation to the results which would have been obtained with a constant chronological age.

The mental age range as shown by the same tables extends

[1] These tables have been omitted from this monograph because of difficulties in printing. They have been bound and placed on file in the Department of Psychology, Stanford University, California, and may be borrowed upon request.

from about eight to eighteen years, thus permitting a range of intelligence quotients of about 75 points. Tables V, VII, and IX of Chapter V present the data on the means and standard deviations of the age groups. The measure of intelligence used, the mental age, was that of the Stanford Revision of the Binet-Simon Scale. In every case at least one standard group test was used as a check on the mental ages obtained by the Binet tests. Where considerable lack of agreement was found, the subject was retested with the Binet tests and the results of the two tests averaged. The mental ages as stated in the tables are always those obtained by the Binet tests and are never based upon a group test alone.

To avoid the problem of the possible influence of sex, the numbers of the sexes were kept roughly equal in all of the experiments.

Description of the Tests:

The three tests which were finally selected in accordance with the criteria already given will be designated as follows:

I. Card Sorting.
II. Code Substitution.
III. Abstract Relations.

A detailed description of each follows:

I. CARD SORTING

The task here consisted in sorting a pack of 100 cards bearing supposedly novel and meaningless designs into a case of ten compartments arranged as two rows of ten compartments each. The following diagram will make this arrangement clear:

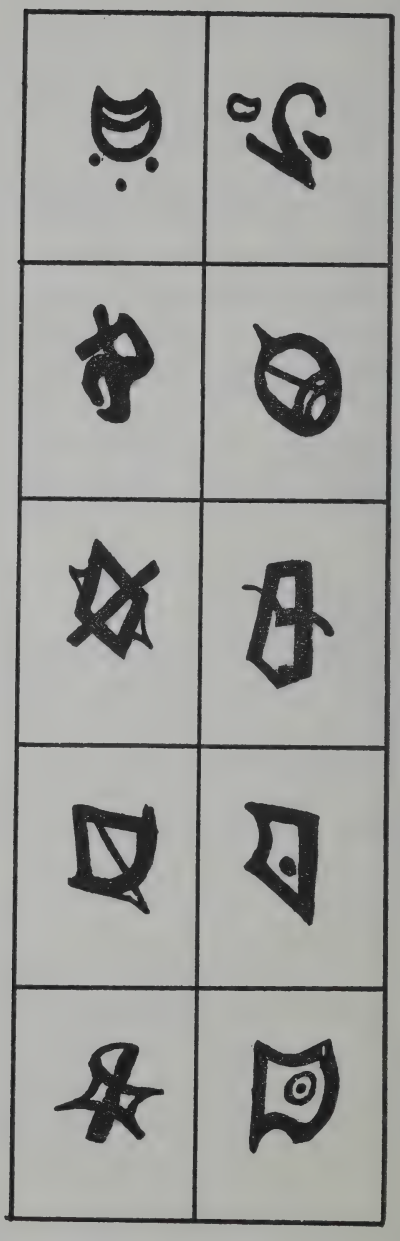

Fig. 1.—Designs on Cards for Sorting Test.

The designs as printed here are full size. The compartments are, of course, greatly reduced. The dimensions of the case were 12 x 28 inches and of the single compartments about 5½ x 5½ inches. The dimensions of the cards were 2½ x 4½ inches.

The pack of cards consisted of ten cards each of ten different suits as determined by the ten designs shown above. The order in the diagram is that of their actual order in the compartments. Each compartment bore a label card corresponding to one of the designs on the cards.

The instructions to the subjects were as given here:

"Here is a pack of 100 cards. Each card has a design printed on it which is probably new to you. There are ten different designs and there are ten cards of each design. (E. shows one of the cards to S. for two seconds.) Under the cover here is a case with ten compartments. Each compartment has a label card and there is a compartment labeled like every kind of design on the cards. (E. raises the cover of the case for two seconds to allow S. a brief inspection.)

"When the signal 'Go!' is given, you are to take the cards one at a time and sort them into the compartments which have the same kinds of label cards. The black line is printed on the cards to show which is the bottom of the card and you should take care to hold them with the black line down. The directions are to go as fast as you can without making mistakes.

"Do you understand? Ready, Go!" (E. removes the cover of the case and at the same time starts the watch. The cover of the case is replaced as soon as the last card is thrown.)

The time was taken to the nearest one-fifth of a second. All errors and changes were noted by the experimenter. The numbers of errors were surprisingly small, averaging fewer than one per trial per subject. Errors were finally ignored for lack of proper method of scoring. The arbitrary practice of adding one second to the time for each error, which has often been used, would not have affected the results to any significant extent.

After the cards were sorted by the subject they were reshuffled by the experimenter in such a way as to avoid the occurrence of two cards of the same suit in consecutive order. Care was also

taken to avoid "runs" of cards in the same order from trial to trial.

Each subject sorted the pack five times each day over a period of ten days (50 trials). The times for the five trials of each day were averaged as the daily score.

An attempt was made to measure the improvement in the mere manipulation of the cards during the ten days of practice by having the subject "box" a similar pack of plain cards five times before the first day's regular practice and five times again at the close of the tenth day's practice. These two sets of boxings were averaged and appear in Table I under the title of "Initial Motor Time" (I.M.T.) and "Final Motor Time" (F.M.T.), respectively. The boxing consisted in throwing the cards one at a time into the compartments taken in the order 1, 2, 3, 4, etc. The difference in the average initial motor time and final motor time was taken as a rough measure of the improvement in the mere manipulation of the cards. The value of this attempted measure will be discussed later.

The practice series was usually continuous except for Sundays. In a few cases both Saturday and Sunday were missed.

Fifty-two subjects took part in this experiment.

II. CODE SUBSTITUTION

The second learning situation was that of transcribing a chapter from Oliver Twist which had been prepared in the code symbols. A second chapter of the same work was provided for translation into the code symbols. Each subject was given a key card bearing the code. This was kept before the subject during the practice until such a time as its use was voluntarily abandoned. The key to the code is given herewith.

The daily practice consisted of the translation for ten minutes from the code into English, followed by translation for the same amount of time from English into the code. Two minutes rest period was allowed between the two exercises. The total practice time was therefore twenty minutes a day.

The score for each sort of translation was the number of letters

(or symbols) transcribed correctly in the ten minutes. No additional penalty was added for mistakes other than loss of credit for that letter or symbol.

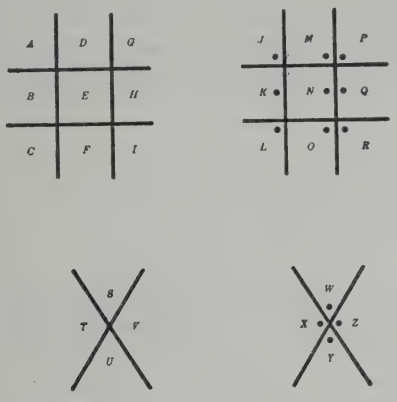

Fig. 2.—Key for Code Substitution Test.

Sixty-six subjects took part in this experiment. Twenty-one continued after the regular ten day period for varying numbers of days.

Samples of the test material will be found in the Appendix.

The exact instructions to the subjects were as follows:

"This test is one in which you have to translate a story written in a code or secret language into English words. You may have seen the code before in some of the tests which we have given. Whether you have seen the code before does not matter, as you will have a copy of the code before you as you work.

"Now look at the key cards which I have given you and we will write a few words together so that you will understand how to use the code when we turn over the page and begin the real work. You watch the code as I write some words on the blackboard. (E. writes 'University of Oregon' slowly, pointing out each symbol on the key card.)

"When the signal to turn is given, turn over the page and begin with the first code sign and write the English letter directly under it. Take the others in order and be sure that you know what each word is before you go on to the next. In this way the meaning of the story will often help you in the translation of the code.

" I am going to give you exactly ten minutes to work and I want to see how many words you can do in that time without making mistakes. **Both speed and accuracy are important.** The real purpose of this test is to see how much improvement you can make each day. For these reasons you should work just as hard as you can to make a good record every day just as if you were playing a game. **Remember, both speed and accuracy are important.**

" Ready, turn, Go! "

The following additional directions for the English code translation were needed:

" Here you have to write the code word under the printed word. Since you cannot easily make the code letters as small as the printed letters, the lines only go half way across the page. You can write straight across the page beginning the line at the left. Ready, Go! "

The code test was used as a semi-group test. The instructions and first day's practice were given individually. Sometimes the subjects worked alone for two or three days. Usually, however, the subjects were formed into small groups of a half dozen after the first day. Judging from careful inspection this plan sacrificed little or nothing in the validity of the results, since any disturbing factors brought about by working in small groups were wholly or nearly wholly compensated for by the added stimulation of group competition. The experimenter checked up on this point by questioning the more intelligent subjects. In fact, it became the usual practice for the subjects to get together after the practice period and compare notes on their respective gains.

III. ABSTRACT RELATIONS TEST

The administration and nature of this test will be made clear by the instructions to the subjects which are given at length here. The introductory directions and explanations were necessarily very detailed and lengthy, due to the fact that the use of subjects with mental ages of eight or nine years made it imperative that every precaution be taken to insure the initial comprehension of

the task. The hope was that failure to make a positive performance in the test would indicate inability to solve the test problems after the instructions were understood and not merely lack of comprehension of these instructions.

A key card was given to each subject and this was kept before him until voluntarily discarded. The key gives the clue to the nature of the problem.

Key

" C IS LARGER THAN A
A IS LARGER THAN B
B IS LARGER THAN D "

" If we arrange the letters in the order of the largest to the smallest, they are: C–A–B–D.

Samples

1	— C plus D equals B	(E. explains)
2	+ A minus B is less than C minus B	"
3	± C minus B is larger than D	"
4	— A minus D is equal to C	"
5	± B plus C plus D is larger than C plus A	"
6	— A plus D is less than B minus C	"
7	— B minus A is less than D minus C	"

" The above samples are already marked correctly. Now begin with problem one of the regular test sheet and work the problems in order. *Be sure that you have answered each problem correctly before you go on to the next one.* Mark those that are *always untrue* with a minus sign (—), those that are always true with a plus sign (+), and those that might or might not be true with both a plus and a minus sign (±). You will be allowed to keep the key card before you at all times as you work. You will be told to stop at the end of fifteen minutes. Ready, Go! "

In order to make as clear as possible the task to be performed, the experimenter demonstrated the solution of the seven samples on the key card as just given. E. said (verbatim):

" You have noticed from the key card that C is larger than A; A is larger than B; B is larger than D, so that if we arrange the letters in the order of the largest to the smallest, they are: C....A....B....D.. **But, you must always remember that**

you do not know how much larger C is than A, or A is than B, or B is than D. All that you know is that C is larger than A, and A is larger than B, and B is larger than D.

" All of the letters stand for numbers that are **more** than zero. However, some of these problems do involve combinations of numbers that are equal to or even less than zero. Examples of these will be explained to you later.

" There is one other point which you must remember or you will make mistakes. It is very important that you do not try to work these problems by letting numbers stand for the letters. These four letters **do not** stand for any certain numbers. For example, if A were equal to 10, then C might be 11 in one problem and more than a million in the next. The same thing is true of all the letters. You do not know how large they are but only that they stand in certain order to each other as the key card states. **You are sure to make mistakes if you try to substitute actual numbers for the letters.**

" Now look at sample 1. C plus D equals B. We would reason out the answer to this problem like this: since C is the largest of all the letters, it must be larger than B. If, then, we add D to C, we would make C still larger than B. The statement that C plus D equals B is always untrue, and it has been marked with a minus sign in front of it. The minus sign means that the statement never could be true. Do you understand? (The explanation is repeated in case the subject fails to comprehend.)

" *Sample 2.* A minus B is less than C minus B. In this sample problem you will notice that the same number is to be subtracted from both sides of the problem. What number is it? (Pause to see whether S. answers. In case S. does not, E. continues.) B is to be subtracted from both sides. Since this is true, we can ignore the B and we have left the statement that A is less than C. This is always true and it has been marked with a plus sign.

" *Sample 3.* C minus B is larger than D. We know that C is always larger than D, but, if B were large enough, C minus B might be less than D. If, however, B is very small, C minus B might still be larger than D. Since we don't know how large any of the numbers are, we can only say that the statement may or may not be true. It is marked therefore with both a plus and a minus sign.

" *Sample 4.* A minus D is equal to C. We know that A is less than C. If now we subtract D from A it will be still smaller

than C. The statement must always be untrue and is marked minus.

"*Sample 5.* B plus C plus D is larger than C plus A. In this problem which letter is found on both sides? (Pause as before for answers.) Since we are adding C to both sides we can cancel out the C and have left B plus D is larger than A. Both B and D are smaller than A. But, the sum of the two may be either larger, equal to, or smaller than A. We have marked it plus and minus because it may or may not be true.

"*Sample 6.* A plus D is less than B minus C. Notice the expression B minus C on the right-hand side. Since C is larger than B, this must equal less than zero. A plus D is more than zero and hence must be larger than B minus C. It is therefore always untrue and has been marked minus.

"*Sample 7.* B minus A is less than D minus C. This problem is very much like the one before except that both sides are equal to less than zero. It is very much harder to decide which is the larger when both are less than zero. Numbers less than zero are called minus numbers and are something like debts. If Mr. A. has $150 and Mr. B. has $20, which is the richer man? (S. answers and E. accepts or corrects as before.) Now, if instead of having these sums of money, A. owes $150 and B. owes $20, which is the richer man? (S. answers as before.) This is why minus numbers are like debts, the larger a minus number appears to be, the smaller it really is. Minus 100 is less than minus 10, and minus 10 is less than minus 1, and minus 1 is less than zero. Look again at sample 7. B minus A is less than D minus C. D is the smallest number of all and C is the largest. If we take the largest of all from the smallest of all, we have left a bigger minus number than if we took the next to the largest (A) away from the next to the smallest (B). But like a debt, the bigger a minus number looks to be, the smaller it really is. B minus A is larger, then, than D minus C and the statement is untrue. (The explanation is repeated once more if asked for. However, no further efforts to explain are made.)

"Now look at the directions at the bottom of the key sheet. You are to reason out these problems one at a time and mark those that are always true with a plus sign, those that are always untrue with a minus sign, and those that might or might not be true with both signs.

"Remember two things: (1) Be sure that you are right before you go on to the next problem, and (2) do not substitute

numbers in place of the letters as you are sure to make mistakes. Ready, turn, go!"

At first glance the instructions appear to be exceedingly involved. However, this was absolutely necessary in order to give the dullest subjects every possible opportunity to make progress in the test. Zero scores could then be interpreted as failures to achieve rather than failure to comprehend instructions. The brighter subjects understood the instructions readily, or were even somewhat amused at the efforts to explain what to many of them was very obvious. A few of the subjects had studied algebra. The inclusion of a few subjects with mental ages below ten years who made zero scores was intentional in order that a close approach to the zero point in ability in this test might be had. In this case it should be pointed out that six subjects who failed to make better than a zero average score for the first five days were allowed to discontinue on the sixth day and their scores for all ten days recorded as zero.

The daily time limit was fifteen minutes. The test material for a given day consisted of 100 problems of the types represented in the seven samples (see also in the Appendix). Three approximately equivalent sets of these were provided. Set I was given on the first, fourth, seventh, and tenth days. Set II on the third, sixth, and ninth days. In case a subject continued longer than ten days, the same order of rotation of the forms was followed.

Because the number of possible responses was limited to three, a correction for chance was necessary. This was done by the method of scoring the number right minus one-half the number wrong. Omissions were not counted either way. In case a subject completed the entire 100 problems of a set in less than the 15 minute time limit, his actual score was multiplied by $\frac{15}{\text{actual working time}}$. This is termed his "rate score." His "accuracy score" was obtained by dividing the number right corrected by the number attempted. An example will make the scoring

clear. Suppose a subject finished a series of 100 problems in 12 minutes and 15 seconds with six omissions and ten mistakes:

Series	100
Omissions	6
Attempts	94
Wrong	10
Right	84
R—W/2	79

$$\text{Rate score} = 79 + \frac{15}{12.25} = 96.7$$

$$\text{Accuracy score} = \frac{79}{94} = 84.0$$

The speed score involves the assumption that the subject would have completed the estimated number had he continued for 15 minutes on similar materials at the same rate of accuracy.

Measured in time units, those subjects who finished in less than the time limit were less practiced at the end of the experiment than the slower subjects. In terms of the number of problems attempted, the rapid workers were more practiced at the end than the slower ones. Since so little is known of the comparative merits of time versus work units, it is wholly conjectural which group of subjects was favored by the plan adopted.

More than sixty subjects took part in this experiment for at least ten days. The method was that of the semi-group plan which was described in the discussion of the code-substitution test.

The subjects were not told their daily scores in any of the tests. If inquiries were made, answers of general encouragement were given. However, many of the subjects spontaneously tried to check up their gains by noting the number of test items attempted from day to day. No efforts were made to prevent the subjects comparing notes on their gains in this way.

CHAPTER IV

The Experimental Results

The results of the three experiments have been recorded in Tables I, II, and III. Because of difficulties in printing, these tables have been suppressed in this report and have been placed on file in the Department of Psychology of Stanford University, and may be borrowed upon written request. A brief characterization of each table is given below.

Table I gives the results for the fifty-two subjects used in card sorting. The daily scores are given as the averages of the five daily trials. Averages for the ten days of practice are also given, such averages including the entire fifty trials. Averages of five preliminary and five final "boxings" are also recorded. These have been described elsewhere. Table I–A, a supplement to Table I, shows the time scores for the first five trials separately, *i.e.*, the five trials entering in to the average score of the first day.

Table II presents the results for the code-substitution experiment. Daily scores are given in terms of the numbers of letters (or symbols) translated in ten minutes. Two figures are given for each day, the upper value being the code to English score and the lower the English to code score. A supplement to Table II, designated as Table II–A, gives the scores for a number of subjects who continued practice more than 15 days, in some cases as long as 40 days.

Table III presents the scores in the abstract relations test. Two daily scores are given for each subject, the upper being the "accuracy" score and the lower the "rate" score. The description of the computation and meaning of these measures has already been given in Chapter III.

It is to be regretted that the full tabular statement of the original scores cannot be reproduced here. The reader will, however, experience little difficulty in following the statistical treatment, since the tables of Chapter V present the means and standard deviations of all subjects for all of the learning tests as well as for chronological age, mental age, etc.

CHAPTER V

Statistical Treatment and Interpretation of the Results

Two general methods were available in the treatment of the experimental data in order to reveal the part played by general intelligence in the rate of learning. The first of these is that of a division of the practicing group into two or three sub-groups upon the basis of the mental ages, *e.g.,* into a "superior," an "average," and an "inferior" group. The same sort of a division might also be made upon the basis of the intelligence quotients, *e.g.,* those above 110, those from 90 to 100, and those below 90. The former has the advantage that it would be less open to the objection that the chronological ages of the subjects are not constant and hence the I.Q.'s alone would introduce a variable factor from group to group.

The second method which was open to use in the present study allows of even greater refinement in the corrections for the varying chronological ages of the subjects. If the daily performances are correlated against mental ages, it is possible to eliminate the influence of chronological age by the use of the method of partial correlations. This necessitates the computation of all the possible intercorrelations between the three variables, viz., mental age, performance, and chronological age. Substantially the same facts will be revealed by each method. The first has the advantage of being adapted to presentation in graphic form, the second of greater statistical refinement. For these reasons both methods will be used although the main treatment of the results will be based upon the method of partial correlations.

In the computation of the coefficients of correlation the Pearson product-moment formula was used in all cases. One general form of this formula is:

$$r = \frac{\Sigma x y}{N \sigma_1 \sigma_2}$$

The probable errors of these correlations were obtained by the formula:

$$\text{P.E.}_r = .6745 \frac{1-r^2}{\sqrt{N}}$$

The formula for the partial coefficients of correlation follows:

$$r_{12\cdot3} = \frac{r_{12} - r_{13}\, r_{23}}{\sqrt{1-r^2_{13}}\ \sqrt{1-r^2_{23}}}$$

In order to secure a check upon the changes in the relative variabilities of the performances of the practicing group from time to time, the Pearson Coefficients of Variation have been computed for each day's performance. These coefficients state the relative variabilities in terms of the ratio of standard deviations to the means. The standard deviation alone is a measure of the variability in terms of gross scores and hence is dependent upon the numerical magnitudes of the units of measurement. The formula for the Pearson Coefficient of Variation is:

$$V = \frac{100\ \sigma}{\text{Mean}}$$

Since the relative heterogeneity of the talent as represented by the daily scores is subject to change, such coefficients are of value in interpreting changes in the magnitudes of the correlation coefficients.

As was stated in the introductory chapter, the selection of the tests finally used in the present study was an attempt to sample a wide range of possible learning situations. For this reason the initial correlations between performance and mental age present some interest as a check upon the wisdom of the original selections. Table IV gives such correlations which have been selected from the larger tables which follow (Tables V, VII, and IX).

TABLE IV

Closeness of Relationship Between the Tests Used and General Intelligence.

	Test	$r_{12\cdot3}$	P.E.
I	Card sorting:		
	Trial 1, first day	0.329	.083
	Average of 5 trials, first day	0.176	.091
II	Code substitution:		
	Code to English, first day	0.699	.043
	English to code, first day	0.666	.046
III	Abstract relations:		
	Rate, first day	0.730	.040
	Accuracy, first day	0.800	.031

The notation "$r_{12\cdot3}$" refers here, as always, to the partial correlation between mental age and performance when the influence of chronological age is eliminated.

It will be seen from this table that ability to sort cards involves relatively little of the ability measured by tests of general intelligence. The mental processes involved in substitution abilities are much more closely related to general mental ability, as is shown by the moderately high correlations obtained. The mental functions involved in the solution of the problems of the abstract relations experiment can be said to be rather closely related to general intelligence as shown by the correlation of $0.800 \pm .031$. These tests, then, do in some measure sample the range of mental functions with respect to the demands made upon intelligence from functions of very low relationship to functions of fairly close identity. It must be remembered that in view of the very large range of talent employed (see Tables VI, VIII, and X for the standard deviations of the mental ages), the exact magnitudes of these correlations have little significance.

The chief interest for present purposes is not concerned with the question of the exact magnitudes of correlations of performance and mental age, but rather with the evidence of *systematic tendencies toward either increase or decrease of such correlations with practice.* Tables V, VII, and IX present the partial coefficients and the intercorrelations between the three variables for

each test. The notations of the variables by number are invariably as follows:

1 Mental age.
2 Performance.
3 Chronological age.

Tables VI, VIII, and X give the means, standard deviations, and Pearson Coefficients of Variation for the separate variables in the different tests.

Table XI gives the correlations between initial and final performance in all of the tests. Initial performance refers to the score on the first day of practice and final performance refers to score on the tenth day of practice.

In order to interpret certain details of the experimental results which apply only to individual tests, each of the experiments will be discussed separately.

TABLE V

Correlations for Card Sorting

1st 5 Trials i.e., first day of Practice	r_{12} M.A. and Score	r_{13} M.A. and C.A.	r_{23} C.A. and Score	$r_{12.3}$ M.A. and Score Independent of C.A.(partial)	N
1	0.434 ± .076	—0.379 ± .080	—0.412 ± .078	0.329 ± .083	52
2	0.403 ± .078	—0.379 ± .080	—0.454 ± .074	0.280 ± .086	52
3	0.192 ± .090	—0.379 ± .080	—0.348 ± .082	0.069 ± .093	52
4	0.219 ± .089	—0.379 ± .080	—0.278 ± .086	0.128 ± .092	52
5	0.211 ± .089	—0.379 ± .080	—0.309 ± .085	0.107 ± .092	52
Days of Practice, i.e., averages 5 daily trials					
1	0.310 ± .085	—0.379 ± .080	—0.430 ± .076	0.176 ± .091	52
2	0.058 ± .093	—0.379 ± .080	—0.402 ± .078	—0.112 ± .092	52
3	0.015 ± .093	—0.379 ± .080	—0.305 ± .085	—0.114 ± .092	52
4	0.038 ± .093	—0.379 ± .080	—0.314 ± .084	—0.092 ± .093	52
5	0.052 ± .093	—0.379 ± .080	—0.175 ± .091	—0.015 ± .094	52
6	0.014 ± .096	—0.388 ± .082	—0.188 ± .093	—0.066 ± .096	49
7	—0.016 ± .096	—0.388 ± .082	—0.153 ± .094	—0.083 ± .096	49
8	—0.077 ± .097	—0.365 ± .084	—0.201 ± .093	—0.164 ± .095	48
9	—0.035 ± .096	—0.365 ± .083	—0.195 ± .093	—0.117 ± .095	49
10	—0.060 ± .096	—0.367 ± .083	—0.041 ± .096	—0.081 ± .096	49

Variables: 1. Mental Age.
2. Score in Seconds.
3. Chronological Age.

TABLE VI

Mean Scores, Standard Deviations, and Coefficients of Variation in Card Sorting

Trials 1–5, i.e., first day of Practice	Mean Mental Age	S.D. Mental Age in Months	Mean Chron. Age	S.D. Chron. Age in Months	Mean Score in Sec.	S.D. Score in Sec.	Pearson Coeff. of Variation	N
1	13—9.1	26.9	13—7.7	13.7	293.5	76.1	25.93	52
2	13—9.1	26.9	13—7.7	13.7	195.5	49.7	25.42	52
3	13—9.1	26.9	13—7.7	13.7	162.5	35.8	22.03	52
4	13—9.1	26.9	13—7.7	13.7	149.0	31.9	21.41	52
5	13—9.1	26.9	13—7.7	13.7	140.8	26.7	18.96	52
Days of practice								
1	13—9.1	26.9	13—7.7	13.7	186.3	37.6	20.19	52
2	13—9.1	26.9	13—7.7	13.7	111.3	24.7	22.22	52
3	13—9.1	26.9	13—7.7	13.7	104.7	21.2	20.27	52
4	13—9.1	26.9	13—7.7	13.7	94.7	23.1	24.39	52
5	13—9.1	26.9	13—7.7	13.7	97.9	21.0	21.42	52
6	13—9.1	27.2	13—8.0	14.1	96.2	22.0	22.86	49
7	13—9.1	27.2	13—8.0	14.1	93.6	20.3	21.74	49
8	13—9.9	27.0	13—7.6	14.0	91.7	19.7	21.47	48
9	13—10.2	26.9	13—7.5	13.8	92.4	22.2	24.00	49
10	13—10.2	26.9	13—7.5	13.8	93.3	19.9	20.31	49

TABLE VII

Correlations for Code Substitution

Day of Practice	r_{12} M.A. and Score	r_{13} M.A. and C.A.	r_{23} C.A. and Score	$r_{12.3}$ M.A. and Score Independent of C.A.	N
Code to English					
1	0.698 ± .043	—0.044 ± .083	—0.129 ± .082	0.699 ± .043	66
2	0.633 ± .050	—0.044 ± .083	—0.028 ± .083	0.633 ± .050	66
3	0.670 ± .046	—0.044 ± .083	—0.010 ± .083	0.670 ± .046	66
4	0.635 ± .049	—0.044 ± .083	—0.019 ± .083	0.635 ± .049	66
5	0.613 ± .052	—0.044 ± .083	—0.012 ± .083	0.613 ± .052	66
6	0.631 ± .050	—0.044 ± .083	—0.079 ± .082	0.630 ± .050	66
7	0.607 ± .052	—0.044 ± .083	—0.084 ± .083	0.613 ± .052	66
8	0.683 ± .044	—0.044 ± .083	0.041 ± .083	0.686 ± .044	66
9	0.613 ± .054	—0.023 ± .086	0.047 ± .086	0.615 ± .054	61
10	0.608 ± .056	—0.049 ± .088	0.054 ± .088	0.613 ± .055	58
English to Code					
1	0.666 ± .046	—0.044 ± .083	—0.020 ± .083	0.666 ± .046	66
2	0.629 ± .050	—0.044 ± .083	—0.081 ± .082	0.628 ± .050	66
3	0.598 ± .053	—0.044 ± .083	—0.057 ± .083	0.597 ± .053	66
4	0.520 ± .060	—0.044 ± .083	—0.028 ± .083	0.520 ± .060	66
5	0.513 ± .061	—0.044 ± .083	—0.075 ± .083	0.511 ± .061	66
6	0.531 ± .060	—0.044 ± .083	—0.036 ± .083	0.530 ± .060	66
7	0.607 ± .052	—0.044 ± .083	—0.010 ± .083	0.607 ± .052	66
8	0.582 ± .055	—0.044 ± .083	0.011 ± .083	0.583 ± .055	66
9	0.519 ± .063	—0.023 ± .086	0.027 ± .086	0.520 ± .060	61
10	0.576 ± .059	—0.049 ± .088	—0.029 ± .088	0.576 ± .066	58

TABLE VIII

Mean Scores, Standard Deviations, and Coefficients of Variation in Code Substitution

Day of Practice	Mean Mental Age	S.D. Mental Age in Months	Mean Chron. Age	S.D. Chron. Age in Months	Mean Score (Lett.)	S.D. Score (Lett.)	Pearson Coeff. of Variation	N
Code to English								
1	14—3.6	34.9	14—1.1	15.0	94.09	50.48	53.65	66
2	14—3.6	34.9	14—1.1	15.0	157.88	62.85	39.81	66
3	14—3.6	34.9	14—1.1	15.0	197.27	69.88	35.42	66
4	14—3.6	34.9	14—1.1	15.0	208.48	65.63	31.48	66
5	14—3.6	34.9	14—1.1	15.0	222.12	66.53	29.95	66
6	14—3.6	34.9	14—1.1	15.0	236.36	71.77	30.36	66
7	14—3.6	34.9	14—1.1	15.0	247.27	77.45	31.32	66
8	14—3.6	34.9	14—1.1	15.0	255.45	90.22	35.32	66
9	14—4.8	35.0	14—1.3	15.1	270.33	89.04	32.94	61
10	14—4.3	35.8	14—1.0	15.1	278.28	90.59	32.55	58
English to Code								
1	14—3.6	34.9	14—1.1	15.0	110.68	55.88	50.49	66
2	14—3.6	34.9	14—1.1	15.0	153.64	54.71	35.61	66
3	14—3.6	34.9	14—1.1	15.0	176.67	61.92	35.05	66
4	14—3.6	34.9	14—1.1	15.0	193.33	62.53	32.34	66
5	14—3.6	34.9	14—1.1	15.0	197.58	61.37	31.06	66
6	14—3.6	34.9	14—1.1	15.0	208.79	67.77	32.46	66
7	14—3.6	34.9	14—1.1	15.0	218.48	75.34	34.48	66
8	14—3.6	34.9	14—1.1	15.0	227.58	83.32	36.61	66
9	14—4.8	35.0	14—1.3	15.1	242.79	89.59	36.90	61
10	14—4.3	35.8	14—1.0	15.1	255.17	91.00	35.66	58

I. CARD SORTING

Table V shows definitely that intelligence[1] offers but slight and temporary advantage in learning to sort cards. If the first five trials which make up the first day's practice are alone considered, it appears that, even in the course of these five trials, the partial coefficients (column headed $r_{12 \cdot 3}$) decreased from $0.329 \pm .083$ for the first trial to $0.107 \pm .092$ for the fifth trial. The value for the third trial is even lower, being $0.069 \pm .093$. If the daily averages of the five trials are compared, it will be seen that these values fell from $0.176 \pm .091$ on the first day to $-0.112 \pm .092$

[1] In the interests of concise expression, the term "intelligence" has been used throughout this discussion as if it were a unitary or elemental factor or mental function. In reality no such definition is implied. For present purposes, no other definition is offered or needed than to point out that intelligence is here defined in terms of what the Binet tests really measure. Intelligence, therefore, is synonymous with Binet mental ages.

on the second day. The coefficients on subsequent days remained slightly negative but not significantly so in view of the large probable errors.

The changes in the relation of chronological age to performance is even more marked in degree. Starting with a correlation of —0.430 ± .076 on the first day, the coefficients approach zero more and more closely each day, the final value being —0.041 ± .096. In view of the negative correlation between the M.A. and the C.A. of the entire group (—0.379 ± .080), the two sets of coefficients are quite in harmony with each other.

One general fact seems evident throughout all of the correlations presented for card sorting, viz., that at the end of practice the subjects have arranged themselves within the group in an order which is quite independent of either their mental maturity or their age. This applies, of course, only within the limits of the age range represented in the experiment. Performance in card sorting, it can be concluded, is controlled by factors of a

TABLE IX

Correlations for the Abstract Relations Test

Day of Practice	r_{12} M.A. and Score	r_{13} M.A. and C.A.	r_{23} C.A. and Score	$r_{12\cdot3}$ M.A. and Score Independent of C.A.	N
Rate					
1	0.720 ± .041	0.092 ± .084	—0.060 ± .085	0.730 ± .040	63
2	0.804 ± .030	0.092 ± .084	0.079 ± .084	0.803 ± .030	63
3	0.819 ± .028	0.092 ± .084	0.053 ± .085	0.818 ± .028	63
4	0.786 ± .032	0.092 ± .084	0.034 ± .085	0.787 ± .032	63
5	0.814 ± .029	0.092 ± .084	0.066 ± .085	0.813 ± .029	63
6	0.789 ± .032	0.092 ± .084	0.096 ± .084	0.787 ± .032	63
7	0.802 ± .030	0.092 ± .084	0.087 ± .084	0.801 ± .030	63
8	0.815 ± .028	0.092 ± .084	0.107 ± .084	0.813 ± .029	63
9	0.813 ± .029	0.095 ± .085	0.076 ± .085	0.811 ± .029	62
10	0.820 ± .028	0.095 ± .085	0.095 ± .085	0.819 ± .028	62
Accuracy					
1	0.793 ± .032	0.092 ± .084	—0.034 ± .085	0.800 ± .031	63
2	0.712 ± .042	0.092 ± .084	0.008 ± .085	0.714 ± .042	63
3	0.748 ± .037	0.092 ± .084	0.035 ± .085	0.748 ± .037	63
4	0.817 ± .028	0.092 ± .084	—0.048 ± .085	0.826 ± .027	63
5	0.829 ± .027	0.092 ± .084	0.017 ± .085	0.831 ± .026	63
6	0.833 ± .026	0.092 ± .084	0.015 ± .085	0.835 ± .026	63
7	0.766 ± .035	0.092 ± .084	0.035 ± .085	0.766 ± .026	63
8	0.837 ± .025	0.092 ± .084	0.043 ± .085	0.837 ± .025	63
9	0.822 ± .028	0.095 ± .085	0.030 ± .086	0.823 ± .028	62
10	0.842 ± .025	0.095 ± .085	0.006 ± .086	0.845 ± .025	62

TABLE X

Mean Scores, Standard Deviations, and Coefficients of Variation for Abstract Relations

Day of Practice	Mean Mental Age	S.D. Mental Age in Months	Mean Chron. Age	S.D. C.A. in Months	Mean Score in Problems	S.D. Score in Problems	Pearson Coeff. of Variation	N
Rate								
1	13—9.1	33.5	13—6.6	7.05	20.04	15.48	77.25	63
2	13—9.1	33.5	13—6.6	7.05	35.75	25.99	72.70	63
3	13—9.1	33.5	13—6.6	7.05	40.91	27.51	67.25	63
4	13—9.1	33.5	13—6.6	7.05	42.54	31.84	74.85	63
5	13—9.1	33.5	13—6.6	7.05	49.56	37.22	75.10	63
6	13—9.1	33.5	13—6.6	7.05	55.48	37.52	67.63	63
7	13—9.1	33.5	13—6.6	7.05	58.81	43.48	73.93	63
8	13—9.1	33.5	13—6.6	7.05	65.95	44.50	67.48	63
9	13—9.0	33.7	13—6.7	7.06	68.39	47.48	69.43	62
10	13—9.0	33.7	13—6.7	7.06	69.68	49.28	70.72	62
Accuracy								
1	13—9.1	33.5	13—6.6	7.05	40.12	24.65	61.44	63
2	13—9.1	33.5	13—6.6	7.05	50.83	29.65	58.33	63
3	13—9.1	33.5	13—6.6	7.05	52.98	29.09	54.91	63
4	13—9.1	33.5	13—6.6	7.05	48.33	29.15	60.31	63
5	13—9.1	33.5	13—6.6	7.05	51.67	31.06	60.11	63
6	13—9.1	33.5	13—6.6	7.05	51.43	29.24	56.85	63
7	13—9.1	33.5	13—6.6	7.05	49.40	31.13	63.02	63
8	13—9.1	33.5	13—6.6	7.05	51.19	29.72	58.06	63
9	13—9.0	33.7	13—6.7	7.06	51.65	30.39	58.84	62
10	13—9.0	33.7	13—6.7	7.06	50.02	31.64	63.25	62

specific nature not related to general intelligence. That these specific factors show some tendency to be stable throughout the course of the learning is shown by the correlation of 0.516 ±.071 (Table XI) between initial and final performance. This finding is quite in accord with the results of Wells, Hollingworth, Whitely, Chapman, Terman, Perrin, *et al.*, previously cited.

The transitory initial correlation of efficiency and intelligence presents especial interest because of the attempts of Gould and Perrin *et al.*, to define intelligence in terms of rapid initial adjustment to a learning situation. In Chapter II these authors were quoted as finding that in maze learning differences in the performances of groups of varying intelligence were chiefly in evidence in the initial stages of the learning. These investigators found that their intelligent group (adults) made poorer initial records than the less intelligent group (children). Such findings are exactly opposed to the results given here for card sorting. It

should also be objected that their use of adults and children as groups differing in intelligence alone, without reference to the other factors which must be involved in maze learning, is probably an unwarranted procedure.

During the practice period, as shown by Table VI, the standard deviations and the means of the time scores are reduced to about one-half of the initial size. This, however, does not involve any marked changes in the relative variabilities of the performances as is shown by the column of Pearson coefficients of variation, the first and tenth days giving almost identical values

TABLE XI

Correlations Between Initial Performance (i.e., first day) and Final Performance (i.e., tenth day) for Each of the Three Tests

	Test	r	P.E.
I	Card Sorting	0.516	.071
II	Code Substitution:		
	Code to English	0.606	.056
	English to Code	0.779	.035
III	Abstract Relations:		
	Rate	0.782	.033
	Accuracy	0.804	.030

at 20.19 and 20.31, respectively. Change in the relative variability of the practicing group, therefore, cannot explain the changes in the magnitudes of the correlations which have been noted.

In order to determine, if possible, whether the absence of correlation between final performance and mental age was due to the fact that the subjects were nearing their limits of improvement and consequently the time scores were becoming more and more measures of the time given over to the purely motor processes of throwing the cards into the compartments, one further set of computations was attempted. The average time required for "boxing" the cards five times on the tenth day of practice was subtracted from the average regular sorting time of that day. This difference, it was hoped, might be a rough measure of any elements in the total mental processes involved other than the purely motor functions. It was thought that any remaining sensory processes in the learning which had been obscured by the

motor factors might thus be separated out from the total time. The difference between the final sorting time and the "boxing" time has been termed "Difference Time." Correlations of this time with mental age and the partial correlations of these two variables excluding chronological age are given in Table XII.

TABLE XII

Correlations of Intelligence and "Difference Time"

		1 M.A.	2 "D.T."	3 C.A.
1	M.A.	.....	0.055 ± .096	—0.367 ± .083
2	"D.T."	0.055 ± .096	.....	—0.149 ± .094
3	C.A.	—0.367 ± .083	—0.149 ± .094	.....

$r_{12 \cdot 3} = 0.0004 \pm .0964$

It will be seen at once that this "Difference Time" proved of no significance as far as its relation to intelligence is concerned. This conclusion is identical with that of Brown (1914:6), who reported a similarly attempted measure as invalid.

II. CODE SUBSTITUTION

The situation with respect to the code test is quite different from that in card sorting. Tables VII and VIII give the data on correlations, central tendencies, and variabilities. In both types of substitution, *i.e.*, code to English and English to code, we find moderately high initial correlation with mental ability. The partial coefficients on the first day are 0.699 ± .043 and 0.666 ± .046, respectively. Both sets of correlations drop slightly during the course of practice. Nevertheless, the decrease is probably not very significant in comparison with the probable errors.[2] The partial correlations on the tenth day are 0.613 ± .055 for code into English and 0.576 ± .060 for English into code translation, the correlations are even lower on intermediate days, *e.g.*, 0.511 ± .061 on the fifth day and 0.520 ± .060 on the fourth day.

[2] By means of the formula for the probable error of a difference, it can be shown that obtained differences in order to be very significant would have to be as large as .25 or larger. This formula reads:

$$\text{P.E. (Diff.)} = \sqrt{\text{P.E.}^2_1 + \text{P.E.}^2_2}$$

This will give values for the P.E. of the difference around .085 where the P.E.'s of the r's are .06. The usual interpretation is that of calling differences uncertain unless the difference is at least 3 times its probable error.

The decrease in the magnitude of the correlations between performance and intelligence is relatively slight and the indications are that the onset of automatization of the mental processes involved would be very much delayed in comparison with card sorting.

The question might be raised again here whether the fall in the size of the correlations (which seems to be most marked from the first to the second day) is merely the result of the decreased variability of the performances of the subjects on the second day as compared with the first, as shown in Table VIII. It is true that the relative variabilities do decrease sharply from the first to the second day, viz., from 53.65 to 39.81 for code to English and from 50.49 to 35.61 for English to code. It is further to be noted that after the second day there is comparatively little change in the relative variability of the subjects. Against this possibility can be urged the fact that the correlations are practically as high on the third and eighth days for code to English as they were at the outset, and yet their Coefficients of Variation are smaller in about the ratio of 53:35. Similar results will be found to hold true of English to code translation, the fluctuations in the sizes of the Pearson Coefficients of Variation seem to be little related to fluctuations in the correlation coefficients. Most of these minor fluctuations are not significantly large in comparison with the probable errors of the coefficients of correlation.

Attention should be drawn to the fact that the range of talent is greater in the subjects practicing with the substitution test than was the case in the card-sorting test, the standard deviations of the mental ages being, respectively, about 35 and 27 months. This difference in the spread of the talent had operated naturally to increase the relative difference between the amount of correlation found between intelligence and card sorting, on the one hand, and intelligence and substitution ability on the other. The range of talent in the subjects used for card sorting is probably not very dissimilar to that ordinarily found within a single school grade but is much greater than that of a single grade for the substitution test.

As shown by the correlations between initial and final ability in the code test (Table XI), the subjects maintain their relative positions with great fidelity, the correlations being 0.606 ± .056 for code to English and 0.779 ± .035 for English to code. This constancy is considerably greater than was found for card sorting.

In general the fall in the correlations during practice is greater in the case of the English to code than in the reverse type of translation. The reason for this is not entirely evident. It might be attributable to the influence of the value of the use of the context in translation of code into English, upon the assumption that the context is a function analogous to comprehension ability in reading and hence offers greater opportunity for the operation of intelligence, or it may be purely a chance phenomenon. There is no experimental evidence which can be cited in proof or disproof of this hypothesis.

III. ABSTRACT RELATIONS TEST

In this test we find a different situation with respect to the influence of intelligence than in either of the two preceding experiments. As shown by Table XI, the initial correlations between mental age and performance are high; the partials excluding the influence of chronological age differences being 0.730 ± .033 for rate and 0.800 ± .030 for accuracy.

In the main, practice seems to increase the correlations slightly, especially in the case of "rate" (Table IX). The situation with respect to "accuracy" is less certain in its interpretation. By reference to Table X it will be seen that the mean daily scores for accuracy did not increase appreciably. From the first to the second day there was a noticeable increase, 40.12 to 50.83, but subsequently the means are almost constant. This was an unforeseen difficulty and one which has probably affected the results of this test very considerably. The interpretation of this situation is undoubtedly to be had in the fact that, during the course of the practice, the subjects, in the main, failed to learn to solve *any more new types of problems*. A given type of problem was either within the ability of the subject at the outset of the

practice or it never became possible for him to make the solution. The improvement, then, perforce, had to come in the direction of the increased speed of solution of the same types of problems with added practice. As is well known, rate scores are less dependent upon intelligence than are accuracy scores, at least for mathematical abilities.

It should be further pointed out that the rate score includes the factor of accuracy as well as rate proper (see Chapter III), and is therefore the better single measure of performance.

The relative variability of the daily accuracy scores remains practically constant save for minor fluctuations which are not constant in direction. This is equally true of the rate scores where improvement is marked.

That the curves of the individuals, if plotted, would not cross to any considerable extent is shown by the correlations of the first and tenth days' performances. These were $0.782 \pm .033$ for rate and $0.804 \pm .030$ for accuracy.

All of the evidence considered, practice in the solutions of abstract problems has not decreased the amount of correlation of this ability with intelligence, and probably such correlations tend to increase with practice within the time limits of the experiments.

GENERAL CONSIDERATIONS

The individual characteristics of the learning processes involved in the three separate tests employed in the present investigation have been discussed at sufficient length in the preceding pages. There yet remains the task of bringing the specific findings together into generalizations regarding the rôle of intelligence in conditioning learning.

The most striking conclusion which can be drawn from these investigations is that it is impossible to generalize about the form of the learning curve *in toto*. We can speak of learning curves in the plural sense, but there seems to be no reason to assume that there exists any one type of learning curve which has universal validity regardless of the mental functions which may be involved and independent of those differences of innate capacity which we

term intelligence or general mental ability. No doubt there are certain characteristics of learning curves which are common to all, such as rapid initial rise, followed by flattening, and final gradual approach to the physiological limits of improvement. What is meant by this categorical denial of any one generalized form of the curve of learning is that evidence has been here presented which suggests at least two important controlling factors in the rate of learning. These two factors are:

(1) *The type of mental function undergoing exercise, and*
(2) *The mental level of the subjects used.*

These issues must also be stated in terms of the problem of the increase or decrease of individual differences under practice. Reference has already been made to the fact that the whole matter of individual differences in learning capacities has never been subject to agreement. Specifically, we can refer again to the findings of Binet that individual differences tended to be effaced with practice, at least for such simple tasks as cancellation tests of various types. Spearman and Krüger have already been quoted to the contrary in their refiguring of Oehrn's data on continued adding. Burt's results were inconclusive in the main and cannot be held to support either contention. On the other hand, Thorndike has adhered firmly to the conviction that those differences present in performance at the outset due to man's original nature are markedly increased by continued exercise. Thorndike would corroborate the work of Spearman and Krüger and oppose the position taken by Binet if these findings are accepted at face value without further analysis.

In the light of certain new data which have been presented here, however, it is perhaps possible to reconcile these divergent opinions in considerable measure. These opposed conclusions have probably not taken into account sufficiently the first of the above mentioned factors which have been emphasized in the present study, viz., the effect of the type of mental function undergoing exercise. Binet's tests were almost entirely of the cancellation type, and it is now well established that such tests involve relatively simple mental processes. The work of Thorn-

dike and his students was almost entirely concerned with relatively complex functions such as mental multiplication and adding. The same holds true for the study of Spearman and Krüger. Moreover, considerable new evidence has been presented in the present discussion which serves to show that both conclusions are probably correctly drawn for the materials used, and that the real error involved is merely that of overgeneralization from a too restricted sampling of mental processes concerned in the learning.

In order to examine this general hypothesis more specifically and from several possible angles, the general issue can be divided into at least three more sharply defined questions. These are:

(1) The question of the changes in the relative variabilities of the entire practicing group, *i.e.*, tendencies for the ratio of standard deviation to the mean to change from day to day during the practice. Such ratios are found in the Pearson Coefficient of Variation.
(2) The problem of the increase or decrease of the individual differences in performances in terms of absolute increments when the practicing group is subdivided into a "superior," an "average," and an "inferior" group upon the basis of mental age.
(3) The question of the fate of correlations between mental age and performance during continued practice.

The changes in the relative variability of the entire practicing group have been indicated by the Pearson Coefficients of Variation as given in Tables VI, VIII, and X. In the case of card sorting the relative variability of the group became rapidly less in the first five trials, being 25.93 for trial 1 and falling to 18.96 for the fifth or last trial of the first day of practice. However, if we consider the average daily scores, there is no constant tendency toward change in either direction. The group as a whole represents a condition of no change in relative variability under practice. The rather rapid change within the first five trials is a very transitory phenomenon, and it must be pointed out that the single trials are much less reliable than the daily averages, and hence are

not strictly comparable to such averages. The chief significance of this stability of the Pearson Coefficients of Variation is probably that they offer evidence that changes in the correlations of mental age and performance are little affected by changes in relative variability from day to day.

In the case of the code substitution test, the situation with respect to relative variabilities is slightly different. In both kinds of substitution, there is a marked decrease in the variability from the first to the second day, and little change subsequent to the second day. This change amounts to a difference of from 53.65 to 39.81 for code to English, and from 50.49 to 35.61 for English to code. Again, variability in the relative sense here implied cannot be a factor in change in the magnitudes of the correlations of intelligence and performance.

Finally, in the case of the abstract relations test there is even less change in the magnitudes of the Coefficients of Variation. For reasons already stated, the rate scores are the better single measure. Although the coefficient for the first day is slightly greater than on any other day, it is almost equalled on the fourth and fifth days, and the differences are probably not significant. In the case of accuracy there is absolutely no reason to believe that systematic tendencies toward change are present in either direction.

Taking all three tests together, the relative variabilities are surprisingly constant over the period of ten days of practice. In the first two tests it would appear that there exists a relatively short period in which the members of the practicing groups tend to arrange themselves in a somewhat more homogeneous manner in their individual performances, but that this is a very transitory phenomenon.

In order to discuss the second of the problems to be considered, viz., that of the increase or decrease of the differences between the three subgroups classified as "superior," "average," and "inferior," certain new data must be introduced. These three groups were formed by breaking the total group into the highest, middle, and lowest thirds taken in the order of their mental ages.

For the three tests the divisions were as follows. The numbers correspond to those assigned to the subjects in the tables of the raw data.

	Card sorting	Code	Abstr. Rel.
"Superior" group.....	Nos. 1–17	Nos. 1–22	Nos. 1–21
"Average" group.....	" 18–34	" 23–44	" 22–42
"Inferior" group.....	" 35–52	" 45–66	" 43–63

Tables XIII to XV and Graphs I to V show the mean scores of each of these three groups during each day of the practice.

In the case of card sorting, there is a very marked tendency for the groups to draw together, *i.e.,* to lose the differences present at the outset. This is most rapid during the first five trials. By the second day the three groups have lost their separate identities. In the case of the abstract relations test we find the reverse situation with respect to the absolute gains. In terms of absolute increments the three groups are constantly increasing those differences present in the initial stages of the learning. The curves diverge like a fan. These two tests tend, then, to show opposed tendencies toward convergence or divergence. In the substitution test we find the curves to be rather irregular. However, if the same were smoothed until they approximate best-fitting lines, the

TABLE XIII

Average Time Scores in Seconds for the Superior, Average, and Inferior Groups in Card Sorting

Trials of	Superior		Average		Inferior	
First Day	Sec.	N	Sec.	N	Sec.	N
1	261.4	17	280.8	17	336.7	18
2	176.1	17	189.3	17	218.6	18
3	153.1	17	161.4	17	169.4	18
4	139.6	17	150.6	17	155.7	18
5	134.3	17	140.9	17	146.9	18
Days of Practice						
1	173.1	17	182.9	17	201.6	18
2	111.8	17	109.8	17	117.8	18
3	101.8	17	108.9	17	103.9	18
4	95.7	17	99.0	17	101.2	18
5	93.2	17	102.6	17	97.7	18
6	94.2	16	101.0	16	95.2	17
7	90.3	16	99.6	16	90.9	17
8	89.0	16	98.5	16	87.6	17
9	89.8	17	97.1	16	90.8	16
10	88.8	17	95.9	16	86.7	16

separate curves of the three groups of subjects would be roughly parallel.

The whole range of possibilities in the forms of the learning curves for groups classified upon the basis of mental age can be represented hypothetically by Diagram I which is given here. Type I represents convergence of the curves or decrease of differences in gross improvement under practice. The card-sorting experiment illustrates Type I. Type III presents the situation found to obtain for the abstract relations test. Type II is not exactly represented in our findings, but is theoretically possible, and there is some evidence that the code test approaches this type to some extent.

The third of our three problems is concerned with the fate of correlations between performance and intelligence. It bears certain similarities to each of the other issues which have just been discussed. It has been repeatedly pointed out that changes in the relative variabilities of the practicing group may influence the

TABLE XIV

Average Daily Scores in Code Substitution for the Superior, Average, and Inferior Groups of Subjects

Day	Superior		Average		Inferior	
Code to English	Lett.	N	Lett.	N	Lett.	N
1	134.0	22	102.3	22	59.8	22
2	193.4	22	167.5	22	110.7	22
3	244.3	22	203.7	22	141.9	22
4	254.6	22	206.0	22	162.0	22
5	270.2	22	212.2	22	184.6	22
6	291.0	22	222.4	22	195.5	22
7	306.4	22	237.8	22	195.6	22
8	329.5	22	246.2	22	189.6	22
9	336.8	22	250.7	19	213.0	20
10	346.8	21	256.9	17	222.4	20
English to Code						
1	149.0	22	114.9	22	67.4	22
2	187.5	22	163.0	22	111.3	22
3	215.6	22	183.9	22	133.1	22
4	226.7	22	194.9	22	156.8	22
5	235.4	22	189.3	22	167.3	22
6	248.4	22	200.3	22	174.8	22
7	274.0	22	215.0	22	172.9	22
8	281.5	22	224.8	22	173.9	22
9	301.6	22	225.6	19	185.5	20
10	318.7	21	232.6	17	206.8	20

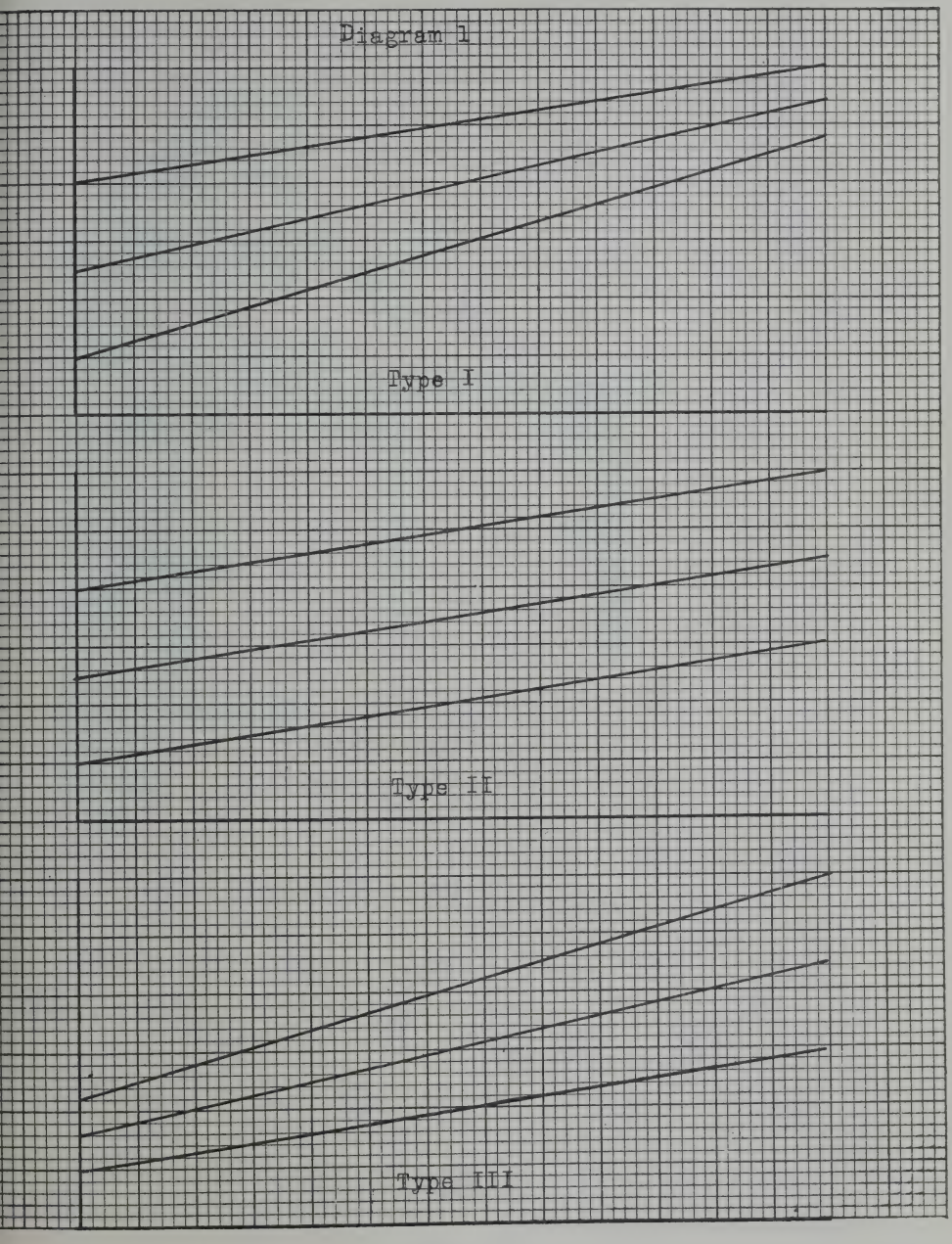

Fig. 3.

magnitude of such correlations because of increase or reduction of the range of talent involved. However, the fact of relative constancy of such relations in all of the tests, at least after the brief initial period, eliminates this factor in the main.

It is, of course, entirely possible, theoretically, that a practicing group can maintain the same relative variability as measured by the ratio of standard deviation to the mean, and yet *the individuals composing the group will be found to approach more and more*

TABLE XV

Average Daily Rate Scores in the Abstract Relations Test for the Superior, Average, and Inferior Groups of Subjects

Day of Practice	Superior		Average		Inferior	
	Prob.	N	Prob.	N	Prob.	N
1	33.9	21	16.4	21	8.8	21
2	63.8	21	27.6	21	14.2	21
3	68.4	21	35.5	21	16.6	21
4	75.4	21	34.5	21	20.9	21
5	88.4	21	41.8	21	22.1	21
6	92.7	21	42.8	21	27.2	21
7	101.7	21	46.6	21	25.3	21
8	110.6	21	52.5	21	31.9	21
9	116.8	21	53.6	20	32.3	21
10	118.5	21	57.2	20	30.2	21

closely to the order demanded by their separate degrees of general mental ability. The reverse of this condition is also possible, *i.e.*, the subjects may day by day lose more and more the relation of their performances to their mental abilities. This, in fact, is what would probably tend to happen where some correlation exists between intelligence and performance in the initial stages of the learning but where automatization sets in rapidly with the result that great changes in the mental functions brought into play in the learning take place during the course of the practice. This point has been repeatedly brought out in laboratory studies.

In general we can expect any one of three situations to be found with respect to the fate of correlations between intelligence and learning:

(1) Decrease in the size of the coefficients of correlation from day to day. If the relative variability of the entire practicing group is constant, this means that the individuals tended to

arrange themselves in their performances in the relative orders suggested by their mental ages at the outset, but that, from day to day, these same individuals became rearranged in orders which were quite or almost unrelated to general intelligence. Individual differences would still be found in the same relative degree as before, but intelligence would

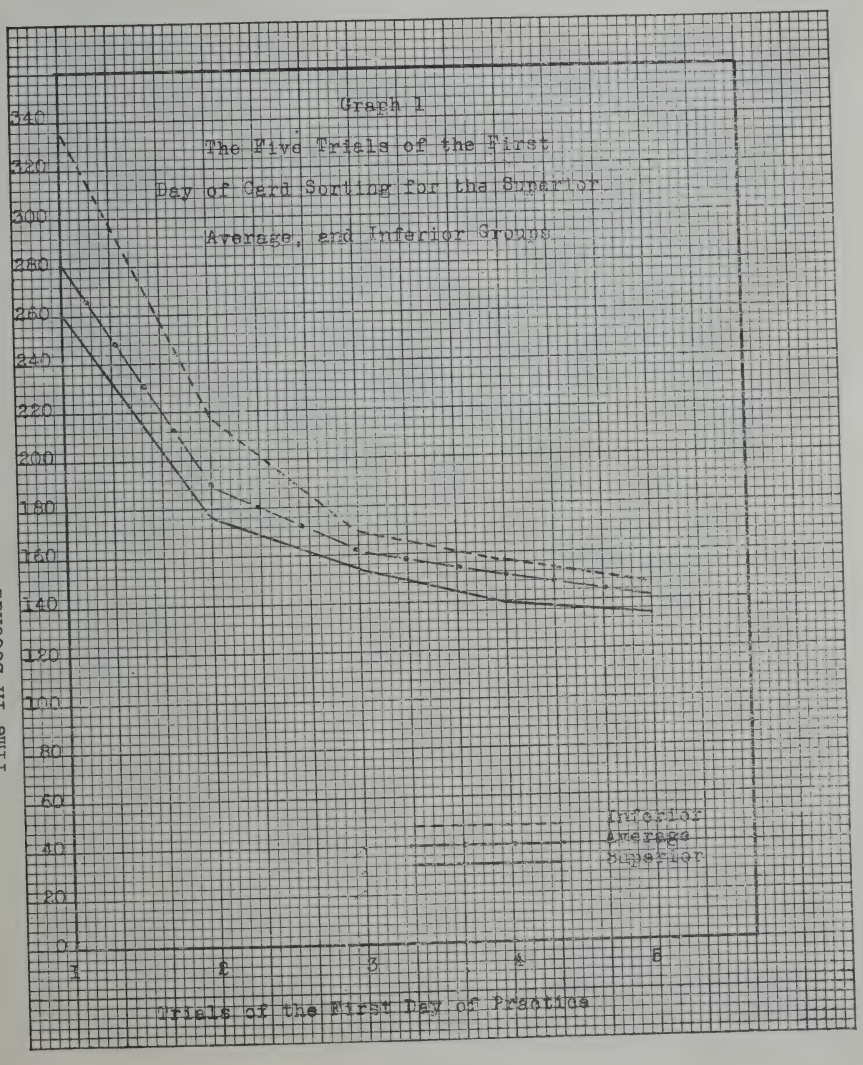

Fig. 4.

not longer be a factor in controlling the positions of the subjects within the group.

(2) The coefficients of correlation might remain constant from day to day. Changes in position of individual members of the group would still be possible, but these changes would probably be relatively small in extent and not constant in direction with reference to the order demanded by the mental

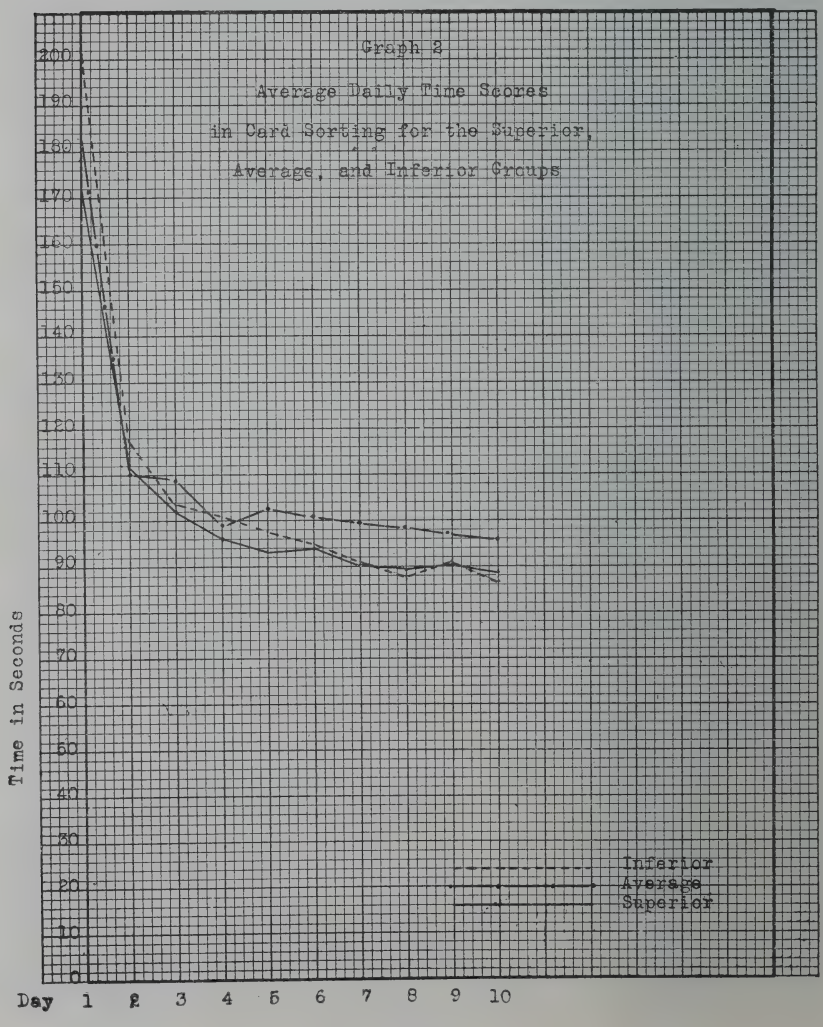

Fig. 5.

ages of the subjects. As before, the relative variability of the group as a whole might remain constant.

(3) The correlations between performance and mental age might be found to be increased with practice. Here again the relative variability of the entire group might not change from day to day, but the individuals composing the group would

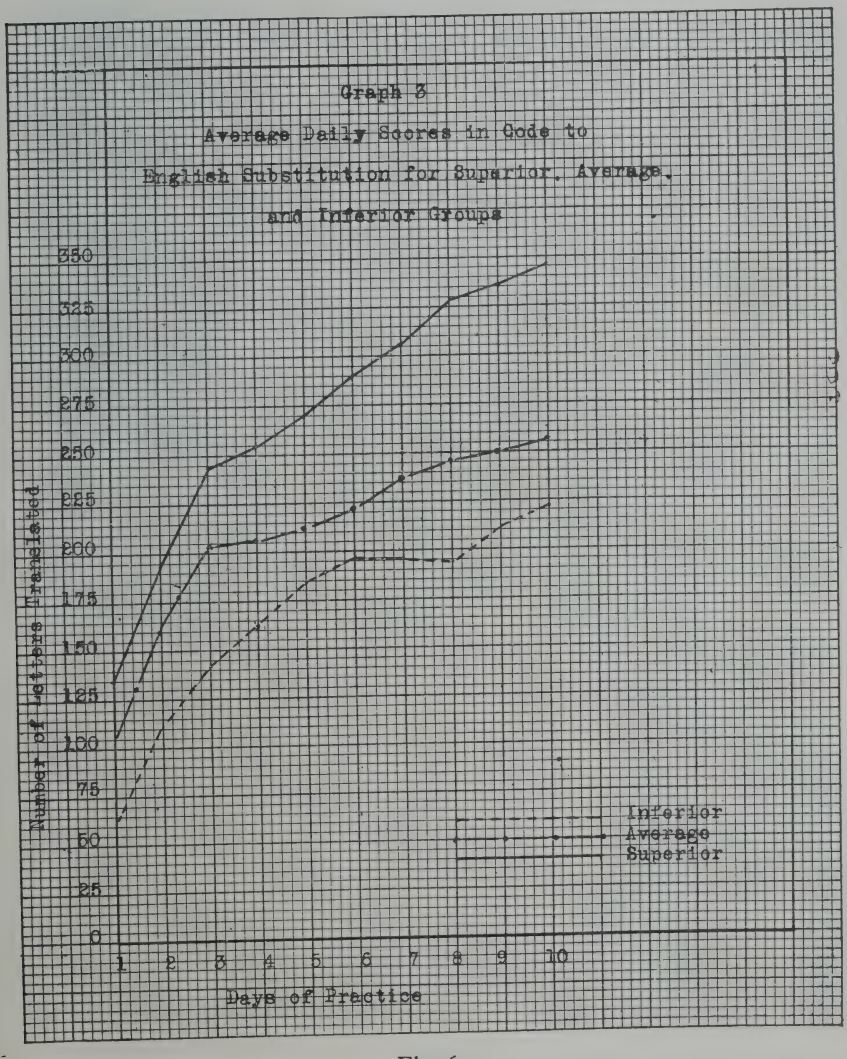

Fig. 6.

be found to be approaching more and more closely the order demanded by their mental ages.

These three possibilities are admittedly hypothetical in part. Each carries with it certain further corollaries. One of these is the question of correlation between initial and final performance.

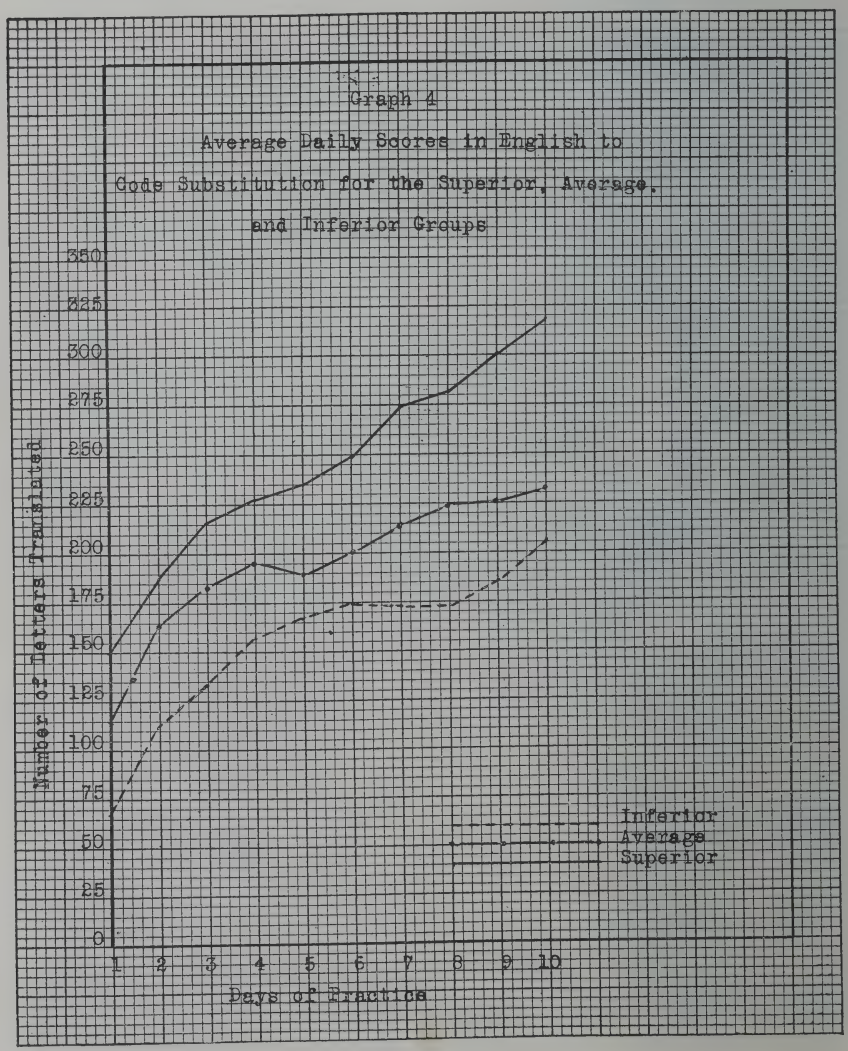

Fig. 7.

The first situation demands a relatively lower correlation between the positions of the subjects at the start and at the finish of practice. The curves of individual subjects are likely to cross and recross toward the end of practice. However, loss of all correlation between mental age and performance is possible with-

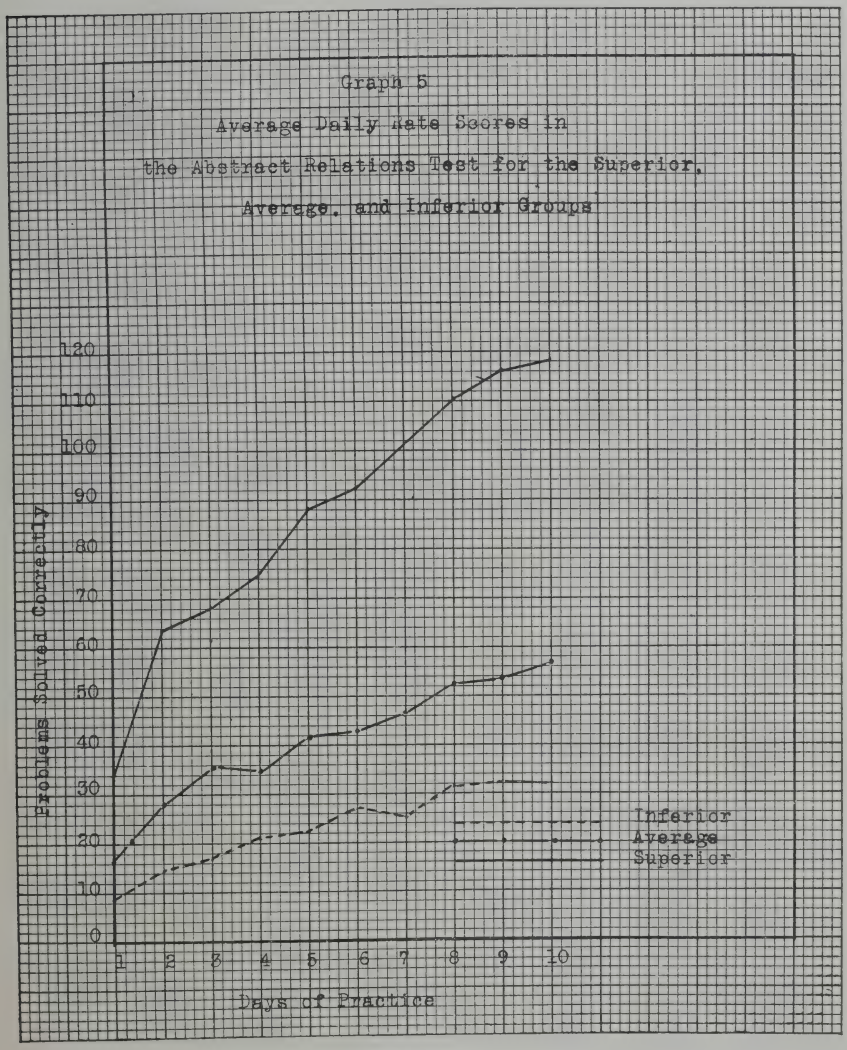

Fig. 8.

out loss of correlation between initial and final positions. This is shown by the card-sorting test where the initial correlation of intelligence and performance rapidly fell to zero although the correlation between the performances of the first and last days was $0.516 \pm .071$. Crossing of the individual curves would probably be slight in the second situation, *i.e.*, where the correlations of performance and intelligence are practically constant. The amount of crossing of individual curves, or what is the same thing, the amount of correlation between initial and final performance, would seem to be controlled by two general factors:

(1) Individual characteristics in the improvability of the particular mental function undergoing exercise. These characteristics would be subject to individual differences in different human beings. This would be individual learning capacity in a mental function *per se*. Such individual differences might conceivably be quite unrelated to the differences existing among the same human beings with respect to intelligence or general capacity for learning. An illustration might be found in the learning to control a baseball by a pitcher. If we assume for the sake of discussion that this is a function entirely unrelated to intelligence, a learning capacity for throwing a baseball accurately might be relatively constant for a given individual and at the same time great individual differences in this power could exist. A moderately high correlation between initial and final ability in this act might be entirely possible. The learning curves of such individuals would not cross to any considerable extent. In fact, this situation is realized to some extent in the card-sorting experiment where the initial performance correlated with the final performance to the extent of $0.516 \pm .071$, but after a very brief initial period the performances on successive days were quite unrelated to intelligence. Individual differences were still as great as before in relative terms.

(2) This first factor would be subject to modification by a second factor, viz., the *general* mental abilities of the subjects. This is really a distinction of the nature of that sometimes assumed by psychologists in the discussions of general versus specific factors in talent. In the case of card sorting, intelligence does not appear to exert any influence upon the positions of the subjects in their relative orders of efficiency

after the very first few trials. On the other hand, if we consider a complex function like the abstract relations test or even the code test, we find that intelligence is constantly operative in determining the efficiency of the performance. Since intelligence is a constant factor, *i.e.,* does not change in the course of the experimentation to any significant extent, it should act to supplement the specific factors making for constancy of relative position from day to day, and, on the whole, correlations of initial and final positions might be found to be higher than in those cases where only the specific capacities are concerned. The actual correlations for the first and last days' scores in the code test were $0.606 \pm .056$ and $0.779 \pm .035$ for code into English and English into code, respectively. For rate in abstract relations the coefficient was $0.782 \pm .033$ and for accuracy $0.804 \pm .030$.

If both of these factors are varied in opposite directions such as might be the case with a learning situation presenting zero correlation with intelligence at the outset and rising to perfect correlation (1.00) at the end of practice, we would obtain the maximum of crossing and recrossing of the separate curves of different individuals, together with zero correlation between initial and final positions. This example may not be a real one in the sense that it corresponds to any psychologically possible situation. Its introduction is made purely for the purpose of setting the distinction between the specific and general factors in learning into the sharpest possible contrast. Whether such a situation is ever possible is very doubtful.

Comparison of the Present Results with the Work of Certain Other Investigators:

In Chapter II, devoted to the review of the literature related to the present problem, several references were made to conflicting results and interpretations in the experimental studies of learning. In part, these issues have been discussed as our new data were presented. However, several of these questions have not been thrown into orientation with present results. In some cases it has been possible to reconcile differences of opinion; in others, it will be necessary to leave the differences standing in opposition.

The suggestion was previously made that the apparent contradiction between the work of Binet with cancellation tests and that of Spearman and Krüger and of Thorndike on continued adding and other arithmetical functions has resulted from the fact that they were comparing mental functions which are widely different. When this factor is recognized, our present findings can be held to harmonize the two positions up to the point of rejecting the universality of their generalizations. On the other hand, Jones (1917:13) has been quoted to the effect that, in his opinion, the work of Wells, Chapman, and Hollingworth was opposed to the general conclusions of Thorndike. Jones bases his argument primarily on the fact that Wells found that those subjects who gained most in adding over a period of thirty days did not gain the most in cancellation during the same period of practice. Upon the assumption that card sorting is similar to cancellation in its demands upon intelligence and that the solution of problems like our abstract relations problems involves abilities roughly comparable to those of continued adding, the fact of differential gains in Wells' two tests presents no serious difficulty in its interpretation. In our card-sorting test, the dull subjects gained most and the bright ones least. In the abstract relations test, the situation was reversed, the bright ones gained most and the dull ones least. Our results, then, are in harmony with those of Wells. Again, the apparent conflict need not be accepted as real but can rather be attributed to failure to recognize the fact that learning curves vary markedly in form for various types of mental functions.

However, when we consider the differences in the results obtained for correlations between initial and final abilities, it must be admitted that present results are not entirely in harmony with all of the previous work.

Hollingworth (1914:29) reported correlations between initial and final abilities for six tests with thirteen adult subjects, as follows:

Adding	.15
Opposites	—.08
Color naming	.68
Discrimination	.68
Cancellation	.67
Coördination	.52
Tapping	.23

The values obtained for adding and opposites are strikingly different from those reported for the higher mental functions in the present investigation. In opposition to these figures by Hollingworth are Chapman's results (1914:9). The latter found correlations of initial and final performance of .59 for opposites, .96 for addition, .87 for multiplication, .87 for color naming, and .75 to .85 for cancellation.

Neither of these sets of results can be compared directly with those obtained here. In the first place, Hollingworth's subjects continued their practice for 175 trials. As Hollingworth himself has pointed out, the tests underwent great changes in their psychological characteristics during the course of practice. Moreover, the subjects were but thirteen in number in Hollingworth's study and but twenty-two in Chapman's investigation. All were adults. Exactly the same words were used in each practice period although the order of presentation was changed. The conditions, therefore, were favorable for rapid automatization and marked decrease of intellectual demands from day to day. Nevertheless, it must be admitted that there is a considerable disagreement here which cannot be explained at present.

Whitely (1911:54) found correlations between starting point and gain to be equal to about .50 in such functions as cancellation, discrimination of weights, sorting, and the pencil maze. As has been stated, these results are out of harmony with certain of Whitely's other work as well as with the present study. In our card-sorting experiment the subjects making the poorest initial records gained most during practice, a fact which would demand negative correlation. Thorndike has called attention to the fact that Whitely's scores are not very reliable because they were obtained from only nine subjects.

It is unnecessary to enumerate the many other minor disagree-

ments in the literature of the psychology of learning. Enough evidence, it is thought, has been presented in the present paper, to indicate clearly that important generalizations concerning learning capacities must distinguish the separate rôles of general intelligence and the complexity of the mental functions involved, in addition to those specific factors governing changes of efficiency during practice.

CHAPTER VI

Summary and Conclusions

The main conclusions which have been reached in the course of the present experimentation are as follows:

1. There is no reason to assume that there exists *any one type* of learning curve which is independent of:
   (a) The *type of mental function* which is undergoing practice, and of
   (b) Differences in the *general mental abilities* of the subjects undergoing the practice.
2. With respect to the second of these two factors, *i.e.*, general mental ability, correlations between performance in learning and measures of general intelligence are subject to any one of three possible fates:
   (a) Such correlations may decrease from day to day as was the case with card sorting, or
   (b) Such correlations may remain practically constant from day to day as tended to be the case in code substitution, or
   (c) Such correlations may increase from day to day. There is some evidence that such a tendency existed in the case of the abstract relations test.
3. When subjects are classified upon the basis of mental age into superior, average, and inferior groups, the separate curves of such subjects may:
   (a) Converge during practice as was the case in card sorting, or
   (b) Remain roughly parallel during practice as was practically true of the code substitution test, or
   (c) Diverge during practice as was shown by the rate scores of the abstract relations test.
4. That the correlation between initial and final performances is controlled by two sorts of factors:
   (a) Specific capacities *per se,* which are characteristic of that particular mental function, and

(b) The general factor of the degree of alienation between the mental processes involved in the learning and general intelligence. Where the relation is close the correlations of initial and final efficiencies probably tend to be higher than is the case in mental function more distantly related to general mental capacity.

5. That many of the disagreements among students of learning can be harmonized upon the hypothesis that there is no generalized type of learning curve, but that learning curves are specifically conditioned by the type of mental function and by the differences in the general mental capacities of the subjects.

APPENDIX

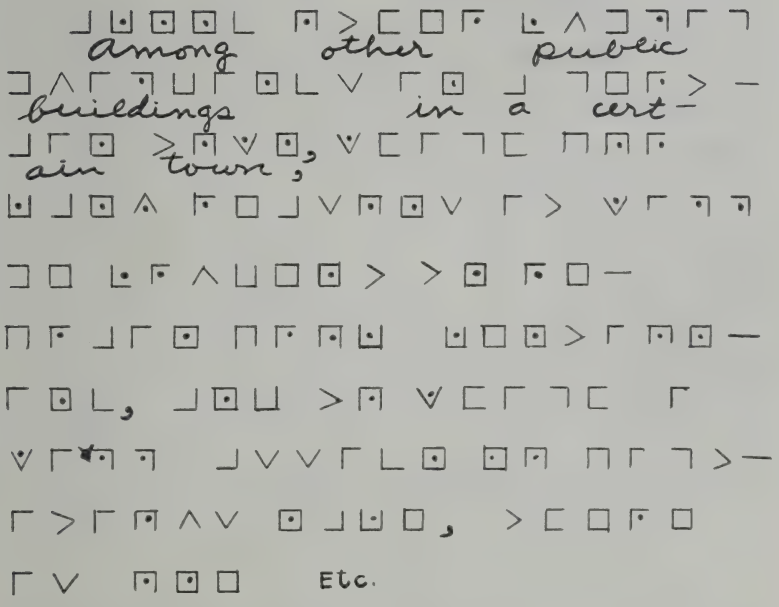

Fig. 9.—A sample of the test materials used for the code to English translation in the substitution experiments. The sample given covers the first few phrases of Chapter I of Oliver Twist. A few of the words have been translated in order to show the method.

A sample of the test materials[1] used for the English to code translation in the substitution experiments. The sample given covers a few phrases from Chapter II of Oliver Twist:

For the next eight or
ten months, Oliver was the
victim of a systematic course
of treachery and
deception. He was
brought up by hand.
The hungry and destitute
situation of the infant
orphan was duly reported
by the workhouse author-
ities to the parish
authorities. The
parish authorities
inquired with dignity of
the workhouse author-
ities, whether there
was no female then

[1] The materials as used were heavily leaded to allow the subjects to write the symbols between the lines.

A sample of the problems used in the abstract mathematical relations test. The first five of the problems have already been answered in order to show the method by which the subjects recorded their answers to the problems.

1	+	B is larger than D
2	+	A plus D is larger than B
3	±	C minus D is larger than B
4	±	C minus A is less than D
5	+	A plus D is less than B plus C
6		A minus B is less than D minus C
7		C minus A is equal to B plus D
8		A plus B plus D is equal to D plus C
9		A plus B plus C is equal to B plus C plus D
10		A minus D is larger than C minus A
11		A is larger than C
12		C plus D is less than B
13		A minus C is larger than B
14		D minus B is equal to A
15		A plus C is larger than D minus B
16		A minus D is less than B plus C
17		C minus A is larger than D minus B
18		A plus C plus D is less than D plus A
19		A plus B plus D is equal to B plus C plus D
20		A minus D is less than B minus D
21		B is less than C
22		A plus C is larger than D
23		A minus D is larger than C
24		D minus C is equal to B
25		A plus D is larger than B minus C
		Etc.

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VOL. XXXIV NO. 8 PSYCHOLOGICAL REVIEW PUBLICATIONS WHOLE NO. 161 1925

Psychological Monographs

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Further Studies in Retroactive Inhibition

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PUBLISHED FOR
The American Psychological Association
By THE PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.
and ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.)
Leipzig (Hospital St., 10); Paris (76, rue de Rennes)

PREFATORY NOTE

The experimental investigations reported in this paper were begun in the fall of 1920, although interest in the problem and some preliminary probing (largely by group methods) goes back several years previous to that date. This section of the work was completed in the summer of 1922, being carried on continuously during the interval. During the progress of these experiments several monographs and articles appeared dealing with certain phases of the work reported in this paper. However, it seemed worth while to continue the work as planned, believing that additional experimental data would either help confirm or refute present theories and experimental conclusions.

In view of the fact that several recent investigators have given very complete reviews of the past theoretical and experimental work done under the caption of retroactive inhibition (see bibliography at the end of the paper, numbers 1, 4, and 5), we will omit this customary procedure. However, we may note that many specific problems yet remain to be investigated under the heading of retroaction. For adequate treatment of these various problems far more work remains to be done than has yet been reported.

We wish to expressly state our obligations to Professor F. C. Dockeray, head of the department of psychology at Ohio Wesleyan, who not only served faithfully as a subject for two years but did all in his power to see that adequate apparatus was provided for the work. Also we wish to thank the administrative officers of Ohio Wesleyan whose kind and generous regard for research made the present work possible. To Professor Pillsbury, under whose direction the work was done, we wish to express our appreciation for his various suggestions and encouragement in the work. Last of all, we must express our appreciation to Mrs. E. B. Skaggs, who not only served throughout as a trained subject but also acted as experimenter when the writer worked as subject.

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PART I. EXPERIMENTAL SECTION

INTRODUCTORY STATEMENTS, DEFINITIONS AND ASSUMPTIONS

Meaning of the term "retroactive inhibition." In this paper the terms retroactive inhibition, retroactive interference or blocking, and retroaction will be used interchangeably. If any given mental (neural) activity B, following a previous learning process A, works detrimentally upon the retention and recall of learning A, we denote the fact by saying that there has been retroactive inhibition. We are using the term, not as any theory, but merely as a handy grouping for a number of phenomena. In psychiatrical work cases are reported under the heading of retrograde amnesia. Here some physical shock or emotional disturbance seems to blot out the possibility of recall of events just preceding the shock. While these cases may involve very different principles of explanation from those facts reported in this paper, we are inclined to classify them under the heading of retroactive inhibition. On the more normal side, if one forms a given series of associations and then turns to other vigorous mental work (with or without emotional aspects), and finds that the original learning is recalled in an unsatisfactory way or not at all, then we indicate this fact as due to retroactive interference.

Subjects used in the experiments. We may classify our subjects into three groups. One group may be called the "trained group." F. C. Dockeray, Mrs. E. B. Skaggs, and the writer constitute this group. All were trained in the art of giving keen and thorough introspections and were able to adjust themselves to the conditions of the experiment.

The second group may be called the "semi-trained group." They were students who were taking advanced courses in psychology following a year of general psychology, involving laboratory work. One of these was a graduate student (R. M. B.). All were faithful in trying to live up to the conditions of the

experiments. Their introspections were usually inferior to those of the trained group.

The third group consists in untrained subjects taken from the writer's classes. The number of records from each of these subjects was usually small, and hence we must rely upon the central tendency of each group for indication of the actual facts. In all cases these subjects were used as checks, although their results were often quite convincing.

The work and rest intervals. As we must in some way compare results under conditions where mental activity follows the original learning with those results where a period of rest followed the learning, it is very necessary to control these two mental conditions. In one case we want an extreme of mental struggle and attention. In the other case we want the subject to be just as passive mentally as possible—to relapse into a condition of lazy, passive perception. We have used the term Work Interval to denote a period of vigorous mental activity. The term Rest Interval denotes a period of relative mental quietude and relaxation. We have made no attempt to secure a graded series of mental conditions ranging from one of these extremes to the other. Our best rest period never represents complete passivity (this presumably would be death), but merely a condition of relatively little thought and effort.

We believe that, on the whole, our subjects have been fairly successful in taking these two mental attitudes, one of work and one of rest. Each subject was told as clearly as possible our conception of a good rest and a good work period. In the rest interval the subject was urged to relax and assume a lazy, indifferent attitude. He was told not to worry about the score he made and to get away from the learning material as far as possible. If at any time some part of the original learning came to mind he was to take a discouraging attitude toward it and get it out of his mind as best he could. In the case of the work interval he was told to work as if his "life depended upon it."

Introspections. The introspections are absolutely essential in the following experimental work. Without these introspections the experimenter is unable to classify the rest and work interval.

Only a complete history of what went on in the subject's mind can permit the experimenter to say that "this is a good rest period free from any return to consciousness of the original learning material," or "this is a fair rest period in which fragments of the original learning came to mind," etc. It is upon the introspections of the three trained subjects that we have relied for the most part. Our group two (semi-trained subjects), however, contributed valuable introspective reports.

While the introspective reports have not been given in this paper they have been taken carefully and in detail. Several tables and important conclusions have been based entirely upon the introspective reports.

The use of short intervals. Our experiments everywhere employ very short rest and work intervals. Longer intervals were used at first (*e.g.,* fifteen minutes) but very quickly abandoned. Long intervals bored our subjects and made it very hard to control the rest interval. Long intervals put a premium upon all sorts of mental activity. Again, it was almost impossible to get the detailed introspections which we desired after a long interval.

Program of investigation. All experiments were performed individually. The writer was experimenter in all cases excepting when he himself served as subject. In the latter case I. D. S. served as experimenter. The so-called "reconstruction test" was used as test material in Part II (following). In Part III a little work is reported in which unconnected sense words were used as learning material. Nonsense syllables constituted the learning material in Part III of this report.

We have attempted to gain some further data upon several major problems. First, Is there any definite evidence of retroactive inhibition? Here we have compared results after work and rest intervals. Second, Does the temporal position of the interpolated work affect the degree of retroaction? Here we have varied the temporal position of the work interval while keeping other conditions as constant as possible. Third, Is there greater retroaction when the work material is similar or dissimilar to that of the original learning? Is there any relation between

the degree of this similarity and the amount of retroactive inhibition? Fourth, Is retroaction greater in the morning or evening—when the subject is relatively fresh or when fatigued? Fifth, What is the effect of practice in a given learning material upon its susceptibility to retroaction?

PART II. EXPERIMENTAL SECTION

RECONSTRUCTION TEST AS LEARNING MATERIAL

Experiment Series A. Comparison of Rest versus Work Intervals

In this series of experiments our problem may be stated as follows: Is there any positive evidence of retroaction under the conditions of our experiment? These conditions are: using the reconstruction test for original learning; short exposure (learning) of material; short interval of work or rest; addition as the interpolated work; and using the central tendency as index for comparative purposes.

The reconstruction test was used extensively because (1) other workers had used it to some extent (DeCamp and Robinson) and (2) because we found that it lent itself admirably to the experimental needs.

Apparatus and Method: A chess board 12 x 12 inches was framed and covered with glass. Five chess men were used, viz., the queen, castle, bishop, knight, and pawn. A large white cardboard 20 x 24 inches was arranged to slide up and down on a horizontal rod above the table, being used to screen the chess board and experimenter from the subject when needed. A stop watch was used in the timing.

The subject sat on one side of the table, the experimenter on the other. The screen being down, E. arranged the chess men on various spots, under a prearranged schedule. At a warning signal of "ready" E. lifted up the screen and exposed the chess formation. S. was then given fifteen seconds in which to study the arrangement. The card was then dropped. The experiment now took one of two forms, as the case might be. Either (1) S. relaxed and was at rest for a given interval or (2) S. worked attentively adding columns of two place numbers. Three differing intervals have been used, namely, a half minute, a minute, and

a two-minute interval. At the end of the given interval, work or rest, the screen was raised and S. tried to reconstruct the formation. The time was recorded from the time S. began to reconstruct until he signified that he had finished. S. added aloud and a record of his performance was kept. However, the amount of work thus done in the work interval is nowhere given in this paper, as it was found to be a relatively constant factor.

The errors are calculated in the same manner as that noted in DeCamp's work. Thus, if the queen was located by E. as four rows up and six columns over to the right our original record read simply, 4–6. If S. replaces the queen as 5–7, then the total errors are one for the row displacement and one for the column displacement, or a total of two errors.

On any given experiment day six individual experiments were done, three of work and three of rest. The intervals were alternated for the following subjects: F.C.D., I.D.S., E.B.S., M.S., F.Bl., and Deus. Consequently each subject in this group knew what experiment was coming next. In the case of subjects R.M.B., R.S., W.A.D., and Sh., the experiments were presented in irregular order, and hence these subjects did not know what to expect next. An interval of from two to three minutes elapsed between each individual experiment in the day's series.

The following tables (I to V, inclusive) give the Means and M.V. for the ten trained subjects and for ten untrained subjects. (It is to be mentioned that only subjects I.D.S. and F.C.D., and E.B.S. knew definitely the nature of the problem.) For the most part the averages for the trained subjects are based upon twenty experiments for each work and rest interval. As we desired some data of a comparative nature between morning and evening conditions, three subjects have thus data for both these times.

SUMMARY TABLE I

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. MORNING RECORDS. ONLY ERRORS CONSIDERED

Subject	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.
E.B.S.	7.9	4.28	5.35	3.72	9.25	6.55	7.00	4.6	15.50	5.9	8.70	6.47
F.C.D.	8.3	5.00	4.30	3.70	10.10	8.30	4.50	4.0	13.50	7.3	5.40	3.20
I.D.S.	8.7	6.50	4.20	3.60	11.20	6.30	5.70	5.2	12.10	7.3	6.30	5.10
M.S.	9.3	4.90	3.00	2.90	10.20	5.40	6.50	3.6	9.40	5.8	8.80	5.90
F.Bl.	.....				8.20	4.80	1.30	1.7	5.10	4.3	2.50	3.00
Deus.	.....				3.80	4.16	6.50	5.8	7.60	5.7	9.80	6.00
R.M.B.	.....				5.67	5.12	7.08	5.0	6.33	3.8	5.75	4.18
W.A.D.	.....				8.12	4.68	6.12	6.2	2.78	2.6	3.89	3.6
R.S.	.....				12.17	5.83	7.17	5.1	12.50	4.6	10.83	5.68
Sh.	.....				11.67	6.59	7.67	5.1	.....			
Total	34.2		16.85		90.38		59.54		84.81		61.97	
Mean	8.55		4.21		9.04		5.95		9.42		6.88	
M.V.	.45		.61		2.07		1.27		3.53		2.24	

EXPLANATORY NOTES.—Each average given for E.B.S., F.C.D., I.D.S., M.S., and F.Bl. is based upon 20 experiments. Averages for Deus. based upon 15 experiments; for R.M.B., 12 experiments; for W.A.D., 8 experiments; for R.S., 12 experiments; and for Sh., 9 experiments. Experiments done between 7 and 9 A.M. for E.B.S., I.D.S., and F.C.D.; between 10 and 12 for other subjects. Time kept same for each subject.

TABLE II

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. MORNING RECORDS. ONLY TIMES CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.
E.B.S.	66.65	25.45	59.20	19.10	74.00	26.70	61.95	32.5	70.00	21.60	68.50	28.40
F.C.D.	43.70	18.50	35.20	18.70	56.60	24.20	40.30	16.8	80.60	32.30	39.80	19.60
I.D.S.	71.30	31.90	57.40	22.00	76.70	30.00	54.30	19.1	96.60	40.60	64.00	27.30
M.S.	81.00	36.00	72.00	38.00	117.00	43.00	92.00	32.0	113.00	36.00	81.00	18.00
F.Bl.	.....				36.70	15.30	26.10	8.0	33.70	19.50	22.50	4.90
Deus.	.....				61.90	34.10	38.30	39.2	99.30	54.50	79.50	41.00
R.M.B.	.....				44.60	19.40	58.90	29.4	50.90	17.60	49.50	14.20
W.A.D.	.....				31.80	6.00	27.10	3.6	23.40	7.60	25.40	7.80
R.S.	.....				95.60	33.10	84.25	19.41	98.60	31.30	83.30	21.60
Sh.	.....				65.20	27.30	42.30	16.9	.....			
Total	262.65		223.8		660.1		555.5		666.1		513.5	
Mean	65.66		55.95		66.01		55.55		74.01		57.05	
M.V.	10.98		8.38		19.85		17.53		26.12		20.20	

EXPLANATORY NOTES.—See notes for Table I.

TABLE III

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. EVENING RECORDS. ONLY ERRORS CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.	Er.	M.V.
E.B.S.	5.25	3.80	5.40	4.70	7.30	5.10	4.75	4.60	12.45	6.80	7.20	4.60
F.C.D.	7.95	5.60	3.70	3.60	6.50	6.50	2.90	2.70	10.60	7.00	3.60	4.10
I.D.S.	7.60	5.20	1.95	1.80	7.80	6.30	4.30	3.99	9.70	6.40	3.20	3.70

EXPLANATORY NOTES.—All averages based upon 20 experiments for each work and rest interval or a total of 120 experiments for the whole table. All experiment series done between 7 and 9 P.M.

TABLE IV

SHOWING AVERAGES AND MEAN VARIATIONS FOR 10 TRAINED SUBJECTS. RECONSTRUCTION TEST. COMPARING WORK VS. REST INTERVALS. EVENING RECORDS. ONLY TIMES CONSIDERED

	0.5′ Interval				1.0′ Interval				2.0′ Interval			
	Work		Rest		Work		Rest		Work		Rest	
	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.	T.	M.V.
E.B.S.	59.95	18.80	60.55	21.80	56.65	24.20	64.20	33.70	74.10	24.00	62.50	19.80
F.C.D.	50.00	16.00	34.00	10.00	48.20	20.80	36.00	15.00	65.00	29.00	52.00	33.00
I.D.S.	72.20	41.20	45.00	22.00	68.80	24.30	58.70	24.50	87.10	34.00	46.40	22.70

EXPLANATORY NOTES.—Same as for Table III.

TABLE V

SHOWING COMPARATIVE RESULTS AFTER WORK AND REST PERIODS FOR 10 UNTRAINED SUBJECTS. AVERAGES BASED ON 6 RECORDS FOR EACH METHOD PER SUBJECT. 1′ INTERVAL USED

Sex	Work Interval Er.	Work Interval Time (″)	Rest Interval Er.	Rest Interval Time (″)
Female	8.5	48.8	2.1	24
Female	11.2	41.2	10.0	36.2
Male	10.0	143.8	6.8	125
Male	4.5	88.7	5.0	87
Female	9.2	103.3	3.8	93.3
Male	12.0	57.3	8.5	51.2
Female	6.7	44.0	6.5	67.0
Female	9.3	70.1	2.7	37.1
Female	10.8	27.0	3.8	24.7
Male	8.5	38.8	9.3	33.3
Total	90.7	663.0	58.5	578.8
M.	9.07	66.3	5.85	57.9
M.V.	1.61	28.7	2.37	28.2

A study of the foregoing data indicate the following: (1) As regards errors made, the case is quite clear for all intervals used—in the case of trained subjects. The performance after the rest is much better than after the work interval.

(A) For the half-minute interval the mean error is more than twice as large after the work than after the rest interval (8.55 as compared with 4.21).

(B) For the minute interval we also find the average error clearly larger for the work interval (9.04 as compared with 5.95).

(C) For the two-minute interval we likewise find more errors after the work.

(2) Considering the above data with regard to individual performance rather than group average, we find:

(A) For the half-minute interval all subjects do markedly better after the rest interval.

(B) For the minute interval, where we have ten cases, eight subjects do better after the rest interval. Deus., one of the exceptions, persistently reported an inability to take a restful, passive attitude, and we suspect that her so-called rest period was as strenuous as her work period. R.M.B., the other exception, reported a similar con-

dition, with the added fact that the adding was very easy for him.

(C) For the two-minute interval (nine subjects) we again find two apparent exceptions, namely, Deus. and W.A.D. We believe that we can easily explain the record of Deus. (as above stated). W.A.D. has a mean based only on eight records and moreover could hardly be called a trained subject.

(3) As regards reconstruction times, our summary table II shows that the mean time is consistently longer for the work than for the rest periods.

(4) The evening records for subjects F.C.D., I.D.S., and F.C.D. (Tables III and IV) show the same thing—there are markedly more errors after the work than after the rest interval.

(5) Table V gives the results for ten untrained subjects. Here only the one-minute interval was used and the records are based upon only six experiments for each work and rest interval. Inspecting the group averages, we find (1) more errors are made after the work than after the rest intervals (9.07 as compared to 5.85) and (2) the reconstruction time is longer after the work. Looking at the data from the standpoint of individual performance, we find that eight out of the ten subjects do better after the rest interval.

Supplementary Control Series

(A)

It may be objected that the reason our subjects did more poorly after the work series was due to the fact that they were fatigued. Or, again, it may be objected that directly after the work the subject was so far removed from a "reconstruction attitude" that he could not get back into this attitude easily and so gave up too quickly. Our work intervals were so short (two minutes being the longest) that the fatigue objection seems out of the question. As six experiments were done in succession, with a small interval between each, there would have to be a most

remarkable oscillation between fatigue and recovery for these short intervals—something quite foreign to what we know of nerve and muscle fatigue. Müller and Pilzecker and Heine have also demonstrated that the above objections are largely insignificant. As regards the attitude objection, we have often found that the subject was " farther away " from the experiment at the end of the rest than after work.

However, a control series of experiments was done, largely to meet the above objections. The reconstruction test was used as before. The exposure time was fifteen seconds. The work consisted in adding two columns of figures simultaneously. The total time elapsing between learning and reconstruction was three minutes. In one case the subject rested for three minutes. In the other case the subject worked immediately for one minute and then rested the last two minutes. This experiment should largely do away with the above objections. Four subjects did the experiments, the order of presentation being irregular in all cases. The averages are given in Table VI.

TABLE VI

Subject	Work Interval Er.	Work Interval Time	Rest Interval Er.	Rest Interval Time	No. Records Based Upon
R.S.	12.3	57.8	4.6	47.6	10
F.C.D.	12.0	37.0	3.45	34.0	9
E.B.S.	5.46	35.8	6.15	48.5	13
I.D.S.	5.80	53.9	3.6	47.2	10

As in the foregoing experiments, we find here a clear retroactive effect for three subjects. E.B.S. alone shows no retroaction; in fact, the reverse is true. We can offer no explanation for this change excepting that through constant practice the subject learned the formations so well that no retroaction could operate.

(B)

There may be a further objection to our view that the work activity in some way actually is detrimental to the previous learning. The introspections of our subjects indicated that many rest intervals were characterized by at least some consciousness of the original learning. This consciousness would vary from a mere

vague and fleeting thought of the learning to a vivid picture repeated a number of times. It may be claimed that the advantage of the rest interval lay in this very fact, namely, that during the rest the subject repeated the learning whereas during the work he could not. The point is a very crucial one. We have carefully gone through the records of subjects F.C.D., I.D.S., and E.B.S., selecting, upon the basis of their introspections, those rest records which were free from any consciousness of the original

TABLE VII

COMPARING AVERAGES OF SELECTED REST INTERVALS WITH WORK INTERVALS AND WITH TOTAL UNSELECTED REST INTERVALS. RECONSTRUCTION TEST. THREE TRAINED SUBJECTS. MORNING AND EVENING RECORDS. ONLY ERRORS CONSIDERED.

	0.5′ Interval		1.0′ Interval		2.0′ Interval	
Subject	Rest	Work	Rest	Work	Rest	Work
Morning Records						
I.D.S.	3.88	8.70	3.00	11.20	8.70	12.1
	N, 17		N, 8		N, 3	
	(4.2)		(3.0)		(6.3)	
E.B.S.	6.30	7.90	7.85	9.25	8.57	15.5
	N, 17		N, 14		N, 14	
	(5.35)		(7.0)		(8.70)	
F.C.D.	4.20	8.30	2.00	8.30	3.20	13.5
	N, 5		N, 3		N, 5	
	(4.3)		(4.5)		(5.4)	
Evening Hour						
I.D.S.	1.60	7.60	4.83	7.80	3.86	9.70
	N, 10		N, 6		N, 7	
	(1.95)		(4.30)		(3.20)	
E.B.S.	3.20	5.35	4.83	7.30	5.44	12.45
	N, 10		N, 12		N, 9	
	(5.40)		(4.75)		(7.20)	
F.C.D.	3.20	7.95	3.50	6.50	3.00	10.60
	N, 4		N, 8		N, 3	
	(3.7)		(2.9)		(3.6)	

EXPLANATORY NOTES.—N represents the number of records upon which the average of the selected rest interval is based. The average given under Work is understood as based upon 20 records. The number in parentheses gives the average for the *total* unselected rest intervals as given in the preceding tables I and III.

learning, with the exception of a short after-image which was always present. These three subjects' records have been chosen because they furnish the most reliable and detailed introspections. Table VII gives the results in summary form. The data show that not only are these selected records confirmatory of our above stated view of retroaction, but the averages for the selected rest intervals are BETTER than the average for the whole series from

which they are taken. We are not surprised at this, for we recall that the subject often said that the consciousness of the original material was vague, indefinite, and merely signified that he was not sure of the learning. While some of the return thoughts of the original learning may have helped the subject in the rest experiments, we believe that there is evidence that the rest period gains its advantage over and above this.

We believe that our data amply justify us in saying that attentive work, following the original learning of the reconstruction test, works in some positive way a clearly detrimental influence on the retention and recall of this original learning.

Experiment Series B. Comparison of Retroactive Effects under Conditions of Fatigue

Tolman (5) found evidence that retroaction is greater for evening than for morning conditions, suggesting that retroaction operates more clearly under conditions of fatigue. Following are two studies which bear upon this problem:

(1) *Comparison of average error and retroaction in the initial and final experiments of a day's sitting.*

It will be recalled that at a given sitting six experiments were performed. We may assume that the subject was at least slightly fatigued at the end of the session. In the following tables (VIII and IX) we present the averages for the initial and final experiments for four trained subjects. Thus, *e.g.,* our day's experiments would be 1, 2, 3, 4, 5, 6—the odd numbers representing work, the even numbers rest, intervals. We thus compare 1 and 5 and

TABLE VIII

Comparing Average Errors and Retroaction in First and Last Experiments in Series

Subject	Position in Series	0.5′ Interval W	R	W–R	1.0′ Interval W	R	W–R	2.0′ Interval W	R	W–R
					Evening Hour					
E.B.S.	First	5.4	8.0	(–2.6)	8.0	5.0	(3.0)	12.0	8.6	(3.4)
	Last	5.2	2.0	(3.2)	6.2	6.5	(–.3)	8.6	5.2	(3.4)
I.D.S.	First	6.5	2.0	(4.5)	3.5	2.4	(1.1)	3.5	2.4	(1.1)
	Last	10.4	2.6	(7.8)	12.1	4.1	(8.1)	13.6	5.2	(8.4)
F.C.D.	First	8.0	6.0	(2.0)	3.0	2.7	(0.3)	5.3	1.1	(4.2)
	Last	10.5	8.5	(2.0)	13.2	4.9	(8.3)	17.5	7.1	(10.4)

2 and 6 in order to answer whether more errors are made in the final experiments of a day's series. To find out whether retroaction is greater or less in the first or last part of the day's series, we have taken the difference between 1 and 2 and compared it

TABLE IX

COMPARING AVERAGE ERRORS AND RETROACTION IN FIRST AND LAST EXPERIMENTS IN SERIES

Subject	Position in Series	0.5′ Interval W	R	W–R	1.0′ Interval W	R	W–R	2.0′ Interval W	R	W–R
					Morning Hour					
E.B.S.	First	7.4	4.6	(2.8)	11.9	7.0	(4.9)	11.9	11.2	(–.3)
	Last	8.6	7.4	(1.2)	8.5	6.4	(2.1)	11.4	7.4	(4.0)
I.D.S.	First	6.6	1.4	(5.2)	8.0	3.7	(4.3)	10.2	3.7	(6.5)
	Last	13.0	6.5	(6.5)	13.3	7.7	(4.0)	13.4	6.4	(7.0)
F.C.D.	First	5.4	2.1	(3.3)	5.3	2.5	(2.8)	8.7	3.1	(5.6)
	Last	9.8	8.1	(1.7)	10.1	6.0	(4.1)	17.1	6.7	(10.4)
M.S.	First	8.0	5.6	(2.4)	8.4	5.9	(2.5)	4.4	4.5	(–.1)
	Last	9.3	1.4	(7.9)	13.0	6.4	(6.6)	11.5	12.5	(1.0)

with the difference between 5 and 6. The figures in parentheses give the retroaction; the other figures give the average error made.

An examination of the preceding tables shows that the average error for both work and rest intervals is larger for the final experiments in a day's sitting as compared with the average error for the initial experiments. Thus we find that out of twenty-one possible comparisons in our tables fifteen give a larger error for the final series, in case of the work intervals. Likewise, in case of the rest intervals, seventeen out of the possible twenty-one comparisons indicate greater error for the final experiments. This may be due to fatigue or some intra-system inhibitory conditions which operate more as the experiments proceed. Both of these factors may work together.

As regards the relative amount of retroaction, we find, comparing the figures in parentheses, that the greater retroaction occurs in the final experiments of the day's series. Out of the twenty-one possible comparisons, fourteen give greater retroaction for the final experiments. In two comparisons there is apparently no difference.

The facts seem fairly clear, indicating that in a learning process extending over about an hour's duration there is more retroaction

for the material learned near the end than for that learned near the beginning of the process. Doubtless we are dealing with a condition of accumulated fatigue plus a slackening of interest or incentives to do one's best in the final experiments of the day's sitting. Also there must be added a possible accumulative system of interferences due to the previous learning. Our subjects constantly reported that they could think of previous constructions and that it troubled them. However, until we disentangle the respective influences of the two above mentioned general factors, we do not feel safe in declaring that our findings support Tolman's conclusions. The presumption would seem to be that retroaction finds a fertile soil upon which to work in the case of fatigue condition or where the learning itself is poor.

(2) *Comparison of retroaction under morning and evening conditions.*

The second part of our present contribution to the question of the relation between retroaction and fatigue is based upon a comparison of retroaction under morning and evening conditions. Subjects F.C.D., I.D.S., and E.B.S. did evening experiments (7 to 9 P.M.) in addition to morning experiments (7 to 9 A.M.). The morning and evening experiments were carried out in alternating fashion, thus ruling out practice effects. No subject did morning and evening experiments on the same day. Our assumption is that the subject is more fatigued in the evening than in the morning—that morning represents a condition of relative freedom from fatigue.

In order to decide whether there is greater retroaction present in the evening experiments certain conditions must be fulfilled: (1) The average error difference between the work and rest series in the morning must be LESS than the average error difference between the work and rest series in the evening; (2) the learning in the evening for the rest series and work series must be as good as that in the morning, otherwise the difference between morning and evening results may be due to difference in degree of learning in the morning and evening.

Using a series of conventional symbols we may put the matter

thus: Let Er.W stand for the average error in the morning work series; let Er.R represent the average error in the morning rest series; let Er.w stand for the average error in the evening work series; and finally let Er.r signify the average error for the evening rest series. Then if there is greater retroaction in the evening, we have

$$\text{Er.W—Er.R} < \text{Er.w—Er.r},$$
$$\text{Granting, Er.r is not} > \text{Er.R}$$

The last condition is satisfied in our experiments. Much to the surprise of subjects E.B.S. and I.D.S., the evening learning was just as good as that of morning after the rest interval. F.C.D., however, demanded more exposure time to fulfil this condition and was accordingly given twenty seconds' exposure instead of fifteen, as in the case of the other two subjects.

TABLE X

	Subject: F.C.D.		
½′ Interval:	W–R = 8.3 –4.3 = 4.0	Slightly greater R. in Evening	
	w–r = 7.95–3.7 = 4.25	(Diff. = 0.25)	
1′ Interval:	W–R = 10.1 –4.5 = 5.6	Greater R. in Morning	
	w–r = 6.5 –2.9 = 3.6	(Diff. = 2.0)	
2′ Interval:	W–R = 13.5 –5.4 = 8.1	Greater R. in Morning	
	w–r = 10.6 –3.6 = 7.0	(Diff. = 1.1)	
	Subject: E.B.S.		
½′ Interval:	W–R = 7.9 –5.53 = 2.37	Greater R. in Morning	
	w–r = 5.25–5.40 = –.15	(Diff. = 2.52—No R. in Evening)	
1′ Interval:	W–R = 9.25–7.0 = 2.25	Greater R. in Evening	
	w–r = 7.3 –4.75 = 2.55	(Diff. = 0.30)	
2′ Interval:	W–R = 15.5 –8.7 = 6.8	Greater R. in Morning	
	w–r = 12.45–7.2 = 5.25	(Diff. = 1.55)	
	Subject: I.D.S.		
½′ Interval:	W–R = 8.7 –4.2 = 4.5	Greater R. in Evening	
	w–r = 7.6 –1.95 = 5.65	(Diff. = 1.15)	
1′ Interval:	W–R = 11.2 –5.7 = 5.5	Greater R. in Morning	
	w–r = 7.8 –4.3 = 3.5	(Diff. = 2.0)	
2′ Interval:	W–R = 12.1 –6.3 = 5.8	Greater R. in Evening	
	w–r = 9.7 –3.2 = 6.5	(Diff. = 0.7)	

The data obtained indicate that for these three trained subjects there is little or nothing to make us believe that retroaction is greater in the evening. Subject F.C.D. shows slightly greater retroaction in the evening when using the half-minute interval, but for the one- and two-minute intervals there is greater retro-

action in the morning. E.B.S. gets slightly more retroaction in the evening for the minute interval but greater retroaction in the morning for the other two intervals. I.D.S. alone gives evidence of greater retroaction in the evening, although in her case there is greater retroaction in the morning for the one-minute interval.

Our subjects are too few in numbers to permit generalization, although for each individual we have tried to make the data conclusive by securing a large number of records. As far as our evidence goes it is contrary to Tolman's notion of greater retroaction in the evening. Moreover, our results make us suspicious that the facts indicated in section (1), preceding, are due to accumulative interference systems rather than to mere fatigue accumulation.

The results of the section above and the preceding section seem in conflict. However, it must be remembered that in section (1) the subject was probably losing his incentives to learn, while in section (2), when working in the evening, the subject was thrown into a condition whereby he put forth extra effort to overcome his general fatigue condition. These differences in incentives and effort are, we believe, very complicating factors, and may explain the above mentioned differences.

Experiment Series C. Effect of Practice on Retroaction

As one becomes more and more practiced with the learning material and the methods of learning that material, does retroaction tend to disappear? Robinson (4) found no retroaction in the case of one of his subjects who was very familiar with the chess board and chess men (reconstruction test). This suggested that the fact might be due to practice.

We present the results for five trained subjects who have twenty experiments to their credit for each work and rest condition for each total interval used. We have taken the averages for the first half of the entire series and compared them with the averages for the last half of the series. The figures in parentheses give the amount of retroaction. By comparing these figures for the first and last half of the total series we should gain

some light upon the question of the relationship between practice and retroaction. The amount of retroaction should be less in the second half of the experiments in case practice decreases retroaction. It should be noted that subject F.C.D. has played chess and that E.B.S. and I.D.S. have played checkers a great deal. Consequently all knew the chess board well before beginning the experiments.

TABLE XI

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: F.C.D.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	8.9	13.9	9.1	15.9	13.0	7.3
Av. 1st 10(R)	4.4 (4.5)	3.9 (10)	5.1 (4)	2.9 (13)	2.7 (10.3)	2.0 (5.3)
Av. 2nd 10(W)	7.6	6.4	17.8	5.5	2.6	14.0
Av. 2nd 10(R)	4.2 (3.4)	5.1 (1.3)	5.7 (12.1)	4.4 (1.1)	3.0 (−.4)	5.0 (9.0)

TABLE XII

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: M.S.

	0.5′	1.0′	2.0′
	Morning		
Av. 1st 10(W)	8.9	11.3	8.9
Av. 1st 10(R)	2.6 (6.3)	4.0 (7.3)	8.0 (0.9)
Av. 2nd 10(W)	9.7	9.1	9.9
Av. 2nd 10(R)	3.5 (6.2)	8.9 (0.2)	9.5 (0.4)

TABLE XIII

COMPARING AVERAGES AND RETROACTION IN FIRST AND SECOND HALF OF EXPERIMENTS

Subject: F.Bl.

	1.0′	2.0′
	Morning	
Av. 1st 10(W)	8.3	7.3
Av. 1st 10(R)	1.3 (7.0)	1.7 (5.6)
Av. 2nd 10(W)	8.0	2.9
Av. 2nd 10(R)	1.2 (6.8)	2.4 (0.5)

TABLE XIV

COMPARISON OF FIRST AND SECOND HALF OF EXPERIMENTS

Subject: I.D.S.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	10.3	9.9	12.7	7.5	5.0	9.2
Av. 1st 10(R)	2.9 (7.4)	5.5 (4.4)	6.5 (6.2)	2.8 (4.7)	4.4 (0.6)	5.3 (3.9)
Av. 2nd 10(W)	7.1	12.4	11.4	8.0	10.6	10.2
Av. 2nd 10(R)	5.4 (1.7)	5.8 (6.6)	6.0 (5.4)	1.1 (6.9)	4.2 (6.4)	1.1 (9.1)

TABLE XV

COMPARISON OF FIRST AND SECOND HALF OF EXPERIMENTS

Subject: E.B.S.

	0.5′	1.0′	2.0′	0.5′	1.0′	2.0′
	Morning			Evening		
Av. 1st 10(W)	8.5	13.4	9.7	6.9	8.1	14.3
Av. 1st 10(R)	6.8 (1.7)	8.6 (4.8)	10.3 (–.6)	7.9 (–1)	8.3 (–.2)	9.1 (5.2)
Av. 2nd 10(W)	7.3	5.1	11.4	3.6	6.5	10.6
Av. 2nd 10(R)	3.9 (3.4)	5.4 (–.3)	7.1 (4.3)	2.9 (0.7)	1.2 (5.3)	5.3 (5.3)

If we take the total number of possible comparisons in Tables XI to XV, inclusive, we find twenty-three. Out of these twenty-three possible comparisons we find that eleven cases signify greater retroaction for the first half of the experimental series. Ten cases give more retroaction in the last half of the experiment series. Two cases are so close together that we may regard them as neutral. Looking at the comparisons by individuals, we note the following: Subject F.C.D. seems to reveal less retroaction as the experiments proceed, although in two comparisons the reverse is true. M.S. and F.Bl. seem to indicate that retroaction decreases with practice. I.D.S. and E.B.S., however, indicate that retroaction increases as the subject goes on with the experiments. In the case of the former there are four comparisons giving greater retroaction in the last half as compared to two cases where the reverse is true. E.B.S. shows the same result.

These results hardly justify us in making any definite statement as to the matter of the relationship between degree of retroaction and practice. The records of F.C.D., I.D.S., and E.B.S. are by far more significant than those of the other two subjects because they were thoroughly trained and have each six comparisons for inspection. Taking these three subjects, we find two experiencing greater retroaction in the last half of the work, while one does the opposite.

Experiment Series D. Effect of Varying the Temporal Interpolation

Müller and Pilzecker (3) and likewise Heine (2) found evidence that the sooner the interpolated work is introduced after the original learning the greater the inhibitory effects. Robin-

son,(4) however, comes to the opposite conclusion. The whole Perseveration Theory is largely at stake here, and the settlement of this point is vital to any theory of retroaction. In view of the conflicting results thus far reported it has seemed well to test further this point.

Again the reconstruction test has been used as original learning material. The total length of the interval between learning and attempted reconstruction has been kept constant. The only varying factor was the temporal position of the interpolated work.

The experiments fall into two different series as follows (figures represent minutes in all cases):

Series I. Total interval 10 mintes:

Method I. Learn—Work 3—Rest 7—Reconstruct.
Method II. Learn—Rest 3—Work 3—Rest 4—Reconstruct.
Method III. Learn—Rest 5—Work 3—Rest 2—Reconstruct.
Method IV. Learn—Rest 7—Work 3—Reconstruct.

Series II. Total interval 5 minutes:

Method I. Learn—Work 2—Rest 3—Reconstruct.
Method II. Learn—Rest 1—Work 2—Rest 2—Reconstruct.
Method III. Learn—Rest 2—Work 2—Rest 1—Reconstruct.
Method IV. Learn—Rest 3—Work 2—Reconstruct.

Series II was done after series I because the first results were rather unsatisfactory so far as indicating anything definite was concerned. In the first series we used multiplication of two by four place numbers as the work. This work was unsatisfactory because it became automatic too readily and appealed very little to the interest of the subjects. Consequently in series II, in addition to reducing the total time to five minutes, algebra problems took the place of the multiplication. These problems were simple equation problems with which the subject could make headway in the short work time.

On any day's sitting the subject was given all the various methods, there being a rest of from two to four minutes between each experiment. To equalize the fatigue factors the methods were rotated from day to day. In series I, E.B.S. alone did all four methods listed above; the others did three.

Nine trained and ten untrained subjects participated in this experiment. Tables XVI and XVII give the individual averages for the trained subjects for both series I and II. Table XVIII gives the averages for the untrained subjects. Graphs I and II will give the same facts for the trained subjects as found in their tables.

SUMMARY TABLE XVI

Showing Averages for Five Trained Subjects. Effect of Varying Rest Interval Between L and W, Reconstruction Test, Series I

	W 3 R 7		R 3 W 3 R 4		R 7 W 3		R 5 W 3 R 2	
Subject	Er.	T.	Er.	T.	Er.	T.	Er.	T.
Deus.	12.60	99.6	7.10	91.0	7.9	11.40	....	....
F.C.D.	8.47	58.5	8.00	51.9	6.1	62.7	....	....
I.D.S.	11.20	72.5	5.95	63.3	10.0	75.0	....	....
M.S.	10.90	122.5	10.60	121.6	11.8	116.6	....	....
E.B.S.	12.40	89.9	9.70	82.5	9.3	74.3	5.4	21.5
Total	55.57	443.0	41.35	410.2	45.1	442.6	5.4	21.5
Mean	11.11	88.6	8.27	82.0	9.0	88.5		

SUMMARY TABLE XVII

Showing Averages for Four Trained Subjects. Effect of Varying Rest Interval Between L and W, Reconstruction Test, Series II

	W 2 R 3		R 1 W 2 R 2		R 2 W 2 R 1		R 3 W 2	
Subject	Er.	T.	Er.	T.	Er.	T.	Er.	T.
F.Bl.	3.13	21.2	1.73	24.7	3.60	24.9	2.53	29.7
E.B.S.	12.00	73.1	7.30	61.6	8.87	66.6	6.00	76.0
I.D.S.	9.87	62.0	8.00	56.7	7.47	52.8	8.87	58.7
R.S.	10.91	74.4	10.50	71.4	8.83	86.9	9.00	75.0
Total	35.91	230.7	27.53	214.4	28.77	231.2	26.40	239.4
Mean	8.98	57.7	6.88	53.6	7.19	57.8	6.60	59.9

TABLE XVIII

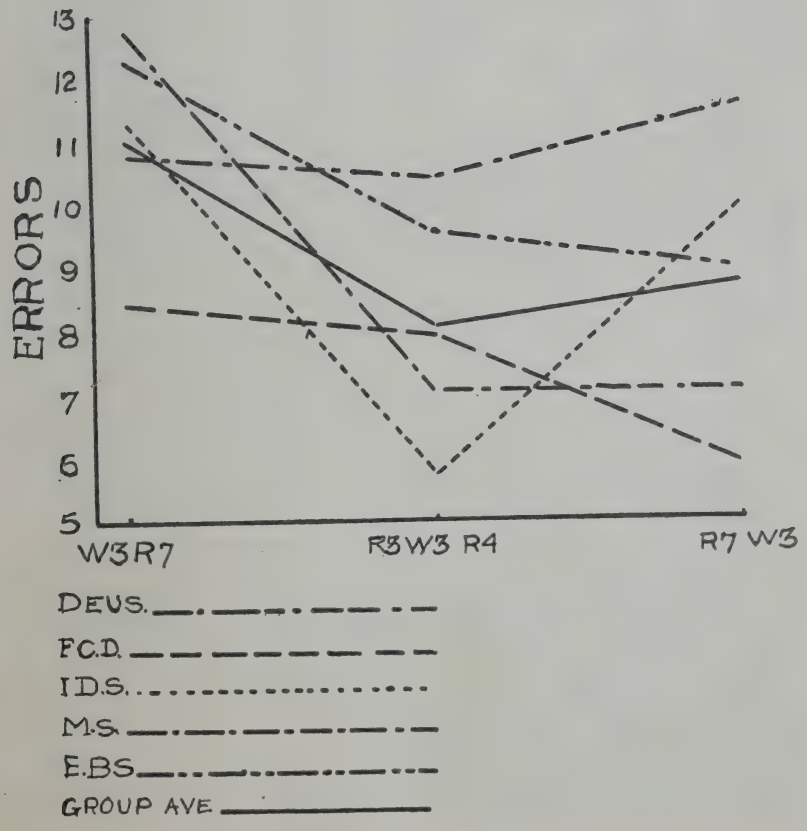
Showing Average Time and Errors for Untrained Subjects. Effect of Varying Rest Interval Between L and W. Based upon Four Records Each. Series II

	W 2 R 3		R 1 W 2 R 2		R 3 W 2	
Sex	Er.	T.	Er.	T.	Er.	T.
Female	5.50	68.5	5.00	56.3	5.80	120.5
Female	1.50	44.0	4.75	36.3	5.75	24.0
Female	6.75	45.8	5.25	42.5	2.00	47.8
Female	5.75	22.3	4.50	50.8	13.50	48.3
Female	8.75	81.7	12.50	90.0	17.5	125.0
Female	11.50	35.8	6.00	51.0	7.5	42.5
Female	15.25	61.5	8.25	35.3	3.5	50.7
Male	13.00	23.0	7.75	26.5	9.0	21.0
Male	2.00	49.0	2.00	52.0	2.0	65.0
Female	3.20	41.6	1.60	25.8	4.6	64.0
Total	73.2	473.2	57.60	466.5	71.15	608.8
Mean	7.32	47.3	5.76	46.7	7.12	60.9
M.V.	3.84	14.3	2.29	13.5	3.83	26.2

Turning first to the averages presented in the foregoing table for series I, we note that most errors are made when the work is introduced immediately after the original learning. However, comparing methods II and IV, we find that the former gives the less number of errors. We cannot account for this unless the work, coming at the end of the interval and thus just before the reconstruction, leaves the subject in an attitude which is unfavor-

GRAPH I

FROM TABLE XXXIV

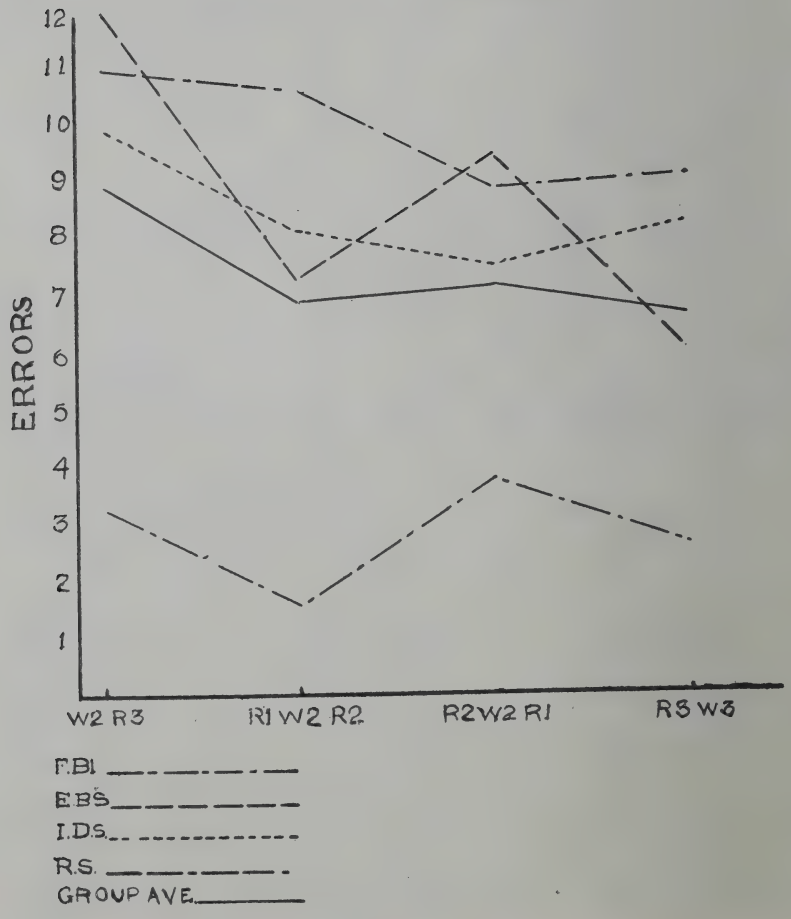


able to recall. Heine (2) found that this difference in attitude was insignificant in the case of nonsense syllables. Also, we have found very often that the subject was " farther away " after a rest than after a work interval, and our experiment testing the above assumption gave no evidence in its favor.

Considering individual performances, which is more important

GRAPH II

FROM TABLE XXXV



here perhaps, we find that F.C.D. gives a nicely graded series (see Graph I). His results fit the perseveration view nicely. E.B.S. has a similar curve, although the differences are not so marked between the various methods. The other subjects all show more errors when the work is introduced immediately but, peculiarly enough, get their best results by the intermediate method.

If we now inspect series II (see Summary Table XVII and Graph II, above), we find, comparing the extreme methods, W2 R3 and R3 W2, that the group average shows more errors when the work is introduced immediately. However, we again fail to secure a graded series, reading from left to right in our summary table or graph, as we might expect if the perseveration view is correct and our methods adequate. A study of the individual records shows clearly that the temporal position of the interpolated work is significant—the " work-at-once " method is the poorest.

A study of Table XVIII, giving the results for the untrained subjects, indicates likewise that the temporal position of the work is important. The most errors are made when the work is introduced immediately after the original learning.

Experiment Series E. The Degree of Similarity Between Interpolated Work and Original Learning

What is the relation between the degree of similarity of work interpolation and original learning as regards the amount of retroaction? Robinson (4) found evidence that retroaction is a function of the similarity between interpolated work and learning. Certainly the problem is a vital one from the standpoint of a theory of retroaction. If the work and original learning are identical, then we have mere repetition, and consequently mere reinforcement of the impression value and the associative bonds. But as the work becomes more and more dissimilar in content and method, where do we find a place where reinforcement stops and interference begins? Obviously two difficulties of experimentation appear. We must work out *a priori* a graded series

of work activities ranging from identical to dissimilar. Also we must see to it that these various work activities are equally taxing, equally interesting and absorbing. Both desiderata are difficult to attain.

In the following experiment series we have tried to obtain further facts upon this problem of degree of similarity. Two series of experiments were carried on (I and II below). As these two series differed considerably we will take them up separately:

Series I

The reconstruction test was used as in previous experiments. The variable factor was the content of the interpolated work. The following outline will give the plan of procedure:

(a) S. studies the chess men arrangement for fifteen seconds. This we designate simply the original learning.
(b) S. rests one minute. E. arranges the work series.
(c) S. studies the interpolated work for fifteen seconds. The content of this work was the varying factor.
(d) S. rests for one minute.
(e) S. is tested for thirty seconds on the interpolated work or else continues the work if it is multiplication. In case of reconstruction type of work, S. tries to reconstruct. In case of picture study, S. tries to recall all details. If S. finished the reconstruction or the recall of the picture details before the thirty seconds were up (this seldom ever happened) he continued to think over what he had just done.
(f) S. rests one minute. E. records the score made on the work and makes ready for the reconstruction of the original learning.
(g) S. tries to reconstruct the original chess formation.

The work material consisted of four varieties for all subjects, excepting I.D.S. and E.B.S., as follows:

I. Similar work. Here S. studied a new chess formation and after one minute tried to reconstruct it.

II. Intermediate form of work. A plain white cardboard was inked in heavy black lines such as to make sixty-four squares. This card exactly covered the chess board and was placed upon it during the work. Five articles were arranged upon these squares, namely, a large white button, large black button, a red checker, a black checker, and a pawn. S. studied this formation and later tried to reconstruct it. Our assumption is that this work has some similarity to the original learning and yet differs in certain respects.

III. Multiplication of two by four place numbers. Some subjects added double columns of figures instead, as the multiplication became automatic.

IV. Study of post card pictures of scenery. Here S. was told to study the pictures with the purpose of later recalling all possible details. These last two forms of work we have thought of as dissimilar and so signified in the following tables.

Three to four minutes intervened between each experiment. A day's experimentation included all four (or three, as the case might be) kinds of work. For I.D.S. and E.B.S. six chess men were used in the work series involving reconstruction work, whereas only five men were used for the other subjects. The order of presentation was rotated from day to day. The subject only rarely knew what kind of work was coming next.

The tables giving averages for this experiment series follow (Tables XIX and XX). Table XLIII is a summary table for nine untrained subjects.

If we will now compare the average error (Table XIX) for either of the dissimilar series (multiplication, or addition, on one hand, or picture study on the other hand) as over against the average error for the similar series, we note that the group means indicate that there is more retroaction where the work is similar. The reconstruction times show nothing. If we take the individual cases, as such, however, we find disagreement. If it is true that retroaction is a function of the degree of similarity, and if we really have three kinds of work differing in degree of

SUMMARY TABLE XIX

DEGREE OF SIMILARITY, SERIES I, RECONSTRUCTION TEST. TRAINED SUBJECTS

	I. Similar		II. Intermediate		III. Dissimilar (Adding)		IV. Dissimilar (Picture)	
Subject	Er.	Time	Er.	Time	Er.	Time	Er.	Time
F.C.D.	10.17	49.7	3.42	47.8	5.93	37.3	6.63	44.9
R.M.B.	10.70	62.1	11.90	66.4	9.80	91.9	15.38	65.4
I.D.S.	15.42	80.9	7.92	59.3	6.67	47.3	....	....
E.B.S.	13.17	53.8	11.25	63.2	9.83	74.1	....	....
R.S.	15.80	65.6	11.70	64.1	16.50	71.5	13.50	62.1
Total	65.26	312.1	46.19	300.8	48.73	322.1	35.51	172.4
Mean	13.05	62.4	9.24	60.2	9.75	64.5	7.1	34.5

EXPLANATORY NOTE.—Averages given based upon 11 records for F.C.D., 10 for R.M.B., 12 for I.D.S., 12 for E.B.S., and 10 for R.S. The times of day when experiments were given were: 8:00 A.M., F.C.D.; 11:30 A.M. for R.M.B.; 7:00 P.M., I.D.S. and E.B.S.; 7:00 P.M., R.S.

TABLE XX

RECONSTRUCTION TEST. DEGREE OF SIMILARITY, SERIES I. SHOWING AVERAGES FOR 9 UNTRAINED SUBJECTS, BASED UPON 5 RECORDS EACH

	Similar		Intermediate		Dissimilar	
Sex	Er.	Time	Er.	Time	Er.	Time
Female	15.0	53.6	12.2	81.0	4.0	59.4
Male	14.8	80.2	9.8	42.8	13.2	36.2
Female	14.4	57.6	9.8	34.8	7.4	39.0
Female	11.8	61.6	6.2	56.4	9.8	56.2
Female	11.8	48.8	6.0	32.8	4.2	34.2
Female	12.0	93.5	13.0	105.2	4.6	66.2
Female	9.0	50.5	9.0	40.5	7.8	32.6
Male	7.0	35.5	7.75	32.0	6.5	23.5
Female	7.2	55.4	4.6	39.4	4.6	35.6
Total	103.0	536.7	78.35	464.9	62.1	382.9
Mean	11.44	59.6	8.7	51.7	6.1	42.5
M.V.	2.48	13.2	2.28	19.5	2.33	12.0

similarity, then our summary table should show a decreasing average error as we read across from left to right. Method I, Similar, should give the greatest error; Method II, Intermediate, should give less errors; Method III, Dissimilar, should give least error. Unfortunately for such nicety of results, this is neither true for the group averages nor for individual means. F.C.D. shows least errors for the Intermediate method, although he makes most errors where the work is similar. I.D.S. and E.B.S. give results according to expectations stated above. R.M.B. gives a medley of results. He makes far more errors after studying the pictures than after any other kind of work; then in decreasing order of errors we find: Intermediate, Similar, and Dissimilar (adding). R.S. gives a similar irregularity of results.

Table XX, the summary table for the untrained subjects, indicates that the similar work causes greater interference than the dissimilar. In fact, their table gives a nicely graded series of errors, as we might expect. This is true for both time and errors.

Our data seem fairly indicative of the importance of the degree of similarity and in so far confirm Robinson's results.

Series II

Feeling that there was the possibility that the different kinds of work used in the previous series might have involved different degrees of effort and attention, an additional series of experiments were done. Also we were urged to carry out these additional experiments to test further the matter of finding the point where similarity ceases to be conducive to retroaction and turns into actual facilitation. Consequently in these experiments we have confined ourselves entirely to the reconstruction test both for the original learning and the work. According to the decreasing degree of similarity as we deduced it, three different work arrangements were used, indicated in the following tables as I, II, and III. Work formation I was very similar to the original arrangement excepting that the chess men were removed in any direction by one square (in a few cases by two squares). Work arrangement II involved the using of the same squares as in the original learning (thus keeping the same pattern) but different men on these squares. We have considered this arrangement as intermediate. Work formation III consisted in as widely different arrangement of the chess men with regard to the original formation as was possible. Thus if the original formation had the men clustered together, in the work they were widely scattered. This we have considered as the least similar work arrangement.

The procedure was similar to that in Series I. Five trained subjects did the experiments. On a given experiment day all three experiments were done twice, with an interval of from three to four minutes between each. Table XXI gives the individual averages.

SUMMARY TABLE XXI

DEGREE OF SIMILARITY, SERIES II, RECONSTRUCTION TEST. TRAINED SUBJECTS

	I			II			III		
Subject	Er.	Time	Er.W.	Er.	Time	Er.W.	Er.	Time	Er.W.
F.C.D.	3.2	35.1	5.7	6.7	14.0	11.8	10.6	51.8	14.0
R.M.B.	9.5	50.9	6.4	18.6	58.9	7.5	11.0	45.1	10.6
I.D.S.	5.8	74.6	3.1	10.1	66.0	3.0	11.9	57.6	4.4
E.B.S.	8.3	42.0	5.1	5.9	41.9	6.7	12.6	73.1	5.9
R.S.	13.6	70.4	6.3	5.7	58.8	5.1	12.4	63.7	10.2
Total	40.4	273.0	26.6	47.0	239.6	34.1	58.5	291.3	45.1
Mean	8.08	54.6	5.32	9.4	47.9	6.82	11.7	58.3	9.02

NOTE.—Following are given the times of day and (in parentheses) the number of records upon which each average is based: F.C.D., 8 A.M. (10); R.M.B., 11 A.M. (10); I.D.S., 7 P.M. (10); E.B.S., 7 A.M. (10); R.S., 7 P.M. (10).

Taking the mean of the group of five subjects, we find that the just slightly dissimilar Series I gives the least mistakes both for the reconstruction of the original learning (note column headed Er.) and for the reconstruction of the work series (see column headed Er.W.). Our so-called Intermediate Series II stands intermediate as regards both sets of error values. Series III, the most dissimilar series, gives MOST mistakes. It is of interest to note that there is an apparent relationship between mistakes in the original learning and the work series. A glance at the summary table shows that the smaller the error for the original learning, the smaller the error for the work, and *vice versa*. This may be indicative of interinhibitory or interference processes working backward and forward. Subjects F.C.D. and I.D.S. show a nicely increasing error value through Series I, II, and III. The increasing order of errors for R.M.B. is I, III, II; for E.B.S., II, I, III; for R.S., II, III, I.

From the standpoint of similarity of individual results our data are not satisfactory. The group mean, however, indicates that the most dissimilar work gives the greatest retroaction. Most of the subjects realized at once, in Work Series I, the fact that the change was slight. Here we approximated a mere repetition—at least definite relationship cues were present in the work arrangement which actually reinforced at times the original learning. Consequently we could hardly expect S. to make many mistakes. In Case II it was different. Although the same squares were covered as in the original learning, the chess men were rear-

ranged on these squares. This tended to bring confusion. The subject realized at once that he was dealing with the same pattern but the complete changing about of the chess men in some way brought confusion. In Case III the work arrangement was as different from the original as possible and so appreciated by the subject.

The introspective aspect of this experiment series has been especially elucidating and suggestive. On the basis of these introspections and the above tables we may venture the following conclusions and interpretations:

(1) Least errors were made in Work Series I. This was because the similarity approximated identity too closely, permitting helpful relationships to be easily noted. This is another way of saying that we had enough identical elements (largely in the form of spacial contiguity) to afford a positive transfer effect, however small.

(2) The Method II was intermediate in errors. This was so because it stood intermediate between helpful similarity (as noted in (1) above) and harmful degree of dissimilarity, as was found in Method III. It offered a greater degree of dissimilarity than Method II, there being less chance to note helpful similarities and differences. On the other hand, there must have been some few helpful relationships in this method because it was not so destructive of retention and recall of the original learning as was Method III.

(3) Method III gave most errors. Here the point of helpful relationship between work and learning (at least the point of relatively harmless relationship) is definitely passed and the work acts detrimentally.

(4) If we make up a series of apparently varying degrees of SIMILAR work, all series of which use the same material and methods of learning as the original learning, then the MORE DISSIMILAR the material the greater the retroaction.

(5) We feel that the above is in no way contradictory to the facts found by Robinson or the results found in our preceding Series I. As Robinson has suggested, if we begin with original learning and work interpolation as identical, then there will be,

of course, reinforcement, a mere repetition. As the work is made more and more different, there comes a time when the reinforcing factors drop out or give way to interfering factors. Let us call this point, just mentioned, Point C. Up to Point C our statement above holds good. Here the greater the similarity the MORE the reinforcement and the LESS the interference. But as we go past this Point C the whole situation becomes reversed, and the more similar the material and method in the work the greater the retroaction, granting equality of attention and effort. This conception of the matter may be put in diagramatic form as shown in Diagram I.

DIAGRAM I

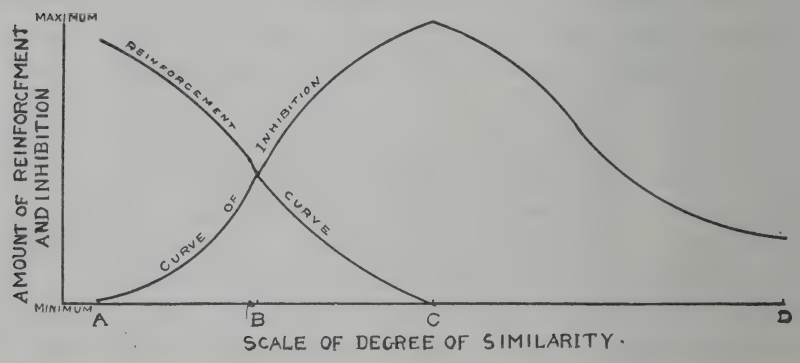


FIGURE 3. *Explanatory Note.*—The above diagram is merely theoretical in its outline. Possibly the curves may be drawn with some mathematical precision in the future. The scale on the left vertical represents the amount of reinforcement and retroaction—two opposed processes. The horizontal scale represents the degree of similarity between the original learning and the interpolated work. Beginning at A where learning and work are identical, as we go to the right there is greater and greater dissimilarity until at D the two are as dissimilar in content and method as is possible. At A inhibition is at a minimum and reinforcement at a maximum (mere repetition); at C the situation is reversed. At D the inhibition curve has fallen but never to the original minimum.

Experiment Series F. Qualitative: Nature of the Rest and Work Intervals

In Part I, Experiment Section preceding, we noted that the validity of our results rested largely upon the nature of the work and rest intervals. However, it is extremely difficult to secure

many " ideal " rest intervals—ideal in the sense that the subject was mentally passive and indifferent and entirely away from the original learning material. If one can secure ten such intervals out of twenty experiments, one is lucky. In a preceding section (see Table VII) we selected those experiments where the rest interval was characterized by practically no consciousness of the original learning after the after-image had faded away. No attention was paid as to whether or not the subject was " active " mentally along other lines. A glance back at Table VII shows the proportion of " ideal " rest intervals to the total of the rest intervals. In the case of the half-minute interval we note that there are 56 ideal rest intervals out of a total of 120; in the minute interval there are 51 ideal rest intervals out of 120; and in the two-minute interval there are 41 ideal rest intervals out of 120. Obviously, as the rest interval is lengthened there is a smaller proportion of " ideal " rest intervals. We found that ten- and fifteen-minute intervals were not only conducive to all sorts of mental activity on the part of our subjects, but they tended to put a premium upon thinking about the original learning. For this reason we have not used long intervals in this investigation.

It must be remembered that an " ideal " rest interval meant no return to consciousness of the original learning. If we would include those intervals where the subject reported merely a vague and indefinite and fleeting consciousness of the learning, our number of " ideal " rests would then be much larger. The cases where a complete " return " of the whole learning came to mind were very few. The consciousness of the original learning thus ranged from a mere fleeting and fragmentary visual or subvocal representation to a review of the whole situation. In general, we may say that as the subject progressed with the experiments he was better able to take an indifferent attitude during the rest intervals. There was always a memory after-image which faded out in the course of one to three seconds.

All subjects reported at times that they felt that the learning material was "near at hand" and ready to " break in." F.C.D. was the subvocalizer of the group. Often the subject would

report that a mere visual image of one or more chess men would flash into mind and out again without being connected with any chess board. At times a part of the chess board or the whole of it would flash into mind without any men placed upon it. Whether these fragmentary and isolated forms of consciousness were any aid toward retaining the original learning is difficult to say. We would hazard a guess that in many cases they were not an aid but actually a hindrance. At times pictures of previous chess formations would come to mind, and most of the subjects felt (rightly or wrongly) that these were a hindrance to them.

In the work interval the subjects seldom ever reported any return to consciousness of the original learning. The after-image or memory after-image was usually cut short in the work intervals. If the work became automatic, then the subject tended to think of the learning or wander off into more interesting fields. On the whole our subjects reported that the work kept them busy.

We may here anticipate the introspective results for the nonsense syllable experiments following by saying that the rest intervals were much freer from any consciousness of the original learning than was the case with the reconstruction test. The sense words were more inclined to return to consciousness than either the reconstruction test material or the nonsense syllables.

PART III. EXPERIMENTAL SECTION

SERIES OF TWELVE SENSE WORDS AS ORIGINAL LEARNING

Will the same results found in the case of the reconstruction test likewise be found in the case of sense words? The following experimental section attempts to answer this question. In all the experiments reported in this section it is to be understood that the original learning consisted in a series of twelve sense words. The words were all one syllable, common words of three, four, and five letters (in a few cases six letters). The great majority of words were nouns, some verbs, and relatively few adjectives and adverbs. As far as possible the words in any one series were so chosen as to have little obvious relation between them. In all series the words were arranged in succession, according to number of constituent letters, as follows: 4, 4, 4, 5, 3, 4, 5, 5, 3, 4, 5, 4. As can be seen, the four-letter words predominated. The same instructions were given the subjects concerning the work and rest intervals as stated in the last section.

Experiment Series A. Comparison of Work versus Rest Intervals

For various reasons, as will be mentioned later, this series of experiments falls into three groups, (1), (2), (3).

Group (1)

Two trained subjects did these experiments. The sense words were printed in large black typewritten type on 3″ x 5″ cards. They were exposed serially and at the rate of one per 1.5 second by moving a long covering cardboard, containing a small lateral window cut into it, down the card. A silent swinging pendulum beat the time.

The words were exposed just once, as we desired to secure but a faint impression. The words having been exposed, there

followed a work or a rest interval, as the case might be. The work consisted in adding ten one place numbers as fast and accurately as possible. One- and two-minute intervals were used. On any given experiment day six experiments were done, that is, three involving work and three involving rest intervals. Two minutes' time elapsed between each experiment. Each day the order of the experiments was reversed, to-day being R, W, R, W, R, W, next time W, R, W, R, W, R. Each subject knew what kind of interval was coming next. The two subjects alternated in giving each other the tests, each subject doing his or her experiments every other day (9 A.M.).

The following table gives the averages based upon twenty experiments for each work and rest interval, employing both one- and two-minute periods. Large R at the head of the column stands for the total number of words correctly recalled. Er. represents words recalled but which were incorrect. T signifies the time for recall. Figures in parentheses give mean variations.

TABLE XXII

	One Minute Interval						Two Minute Interval					
	Work			Rest			Work			Rest		
	R	Er.	T.	R	Er.	T	R	Er.	T	R	Er.	T
I.D.S.	3.9	0.4	88.2	5.4	0.6	82.8	3.1	0.45	97.0	5.2	0.8	79.2
	(1.2)	(0.5)	(24.0)	(1.1)	(...)	(17.8)	(1.4)	(0.54)	(21.6)	(0.9)	(0.8)	(16.1)
E.B.S.	2.9	0.3	75.6	3.2	0.7	70.7	2.3	0.40	72.3	2.2	0.4	72.6
	(1.1)	(0.4)	(18.0)	(1.3)	(0.8)	(16.5)	(1.3)	(0.5)	(12.9)	(1.0)	(0.5)	(14.2)

Inspection of the table shows clearly a retroaction in the case of I.D.S. Subject E.B.S. indicates a slight tendency toward retroaction in the minute interval, whereas in the two-minute interval no retroaction is found.

GROUP (2)

This group of experiments differs from the last in a number of respects. First, the order of presentation was irregular, and consequently S. did not know what interval was coming next. Second, only one interval was used, namely, a three-minute period. Third, S. worked only one minute, resting the last two

minutes before recall. Fourth, two exposures were given instead of one. Fifth, the words were presented by a memory apparatus.

The exposure apparatus used was a modification of the older Wirth machine made by Professor J. F. Shepard at the University of Michigan. The series of sense words were written upon a strip of white paper in the same way as above mentioned. This strip was placed on the rotating drum of the machine and each word exposed serially at the exposure window. As there were fourteen stops during a complete drum rotation, and as we employed only twelve words, there was therefore an exposure of two blank spaces between the two exposures.

The words were exposed serially at the rate of 1.5 second each, two exposures being given. The total exposure time was thus three seconds for each word. Each word was spoken aloud by S., who was instructed to take a discouraging attitude toward forming connections between the words. Other conditions were as in Group (1).

Four trained subjects did these experiments. Table XXIII gives the means and mean variations (latter in parentheses). The averages are based upon nine experiments for each work and rest interval for all subjects excepting R.M.B., who has ten records.

TABLE XXIII

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
Shps.	7.0	77.4	0.3	7.25	73.2	0.78	11 A.M.
	(1.7)	(30.4)	(0.4)	(1.53)	(16.7)	(0.52)	
R.S.	4.89	66.2	0.8	5.89	71.6	0.30	2:30 P.M.
	(2.1)	(17.3)	(0.8)	(1.26)	(9.5)	(0.5)	
R.M.B.	5.1	82.5	0.2	4.89	65.1	0.66	11 A.M.
	(1.2)	(29.1)	(0.3)	(1.0)	(22.1)	(0.6)	
M.Blf.	5.78	48.6	0.8	6.10	50.3	0.78	1:30 P.M.
	(1.63)	(15.1)	(0.7)	(1.23)	(16.1)	(0.69)	
Total	22.77	274.7	2.1	24.13	260.2	2.52	
Mean	5.69	68.7	0.5	6.02	65.0	0.63	

The above table indicates, in the case of three subjects, some retroaction. However, the difference between rest and work intervals was small, while in the case of R.M.B. the rest interval was more unfavorable to retention and recall. While we may say that some retroaction is indicated here, the results are not

striking. The suggestion arose early that perhaps our work interval was too short. In consequence of the poor results obtained above, these experiments were discontinued and a third group begun.

GROUP (3)

The following experiments are exactly similar to the above in all respects except that the work was extended over two minutes instead of one. Thus we have two experiments:

(a) The Work Series: Learn, work 2 min., rest 1 min., recall.

(b) The Rest Series: Learn, rest entire 3 min., recall.

The following table gives the means and mean variations for three trained subjects. All averages are based upon twelve experiments each for the work and rest conditions excepting in the case of F.C.D., who has fifteen records.

TABLE XXIV

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
F.C.D.	5.33	60.5	0.33	6.07	56.5	0.2	8:20 A.M.
	(1.51)	(11.9)	(0.53)	(1.41)	(12.8)	(0.34)	
R.S.	4.66	79.1	0.08	5.16	81.1	0.33	2:30 P.M.
	(1.56)	(12.9)	(0.15)	(1.39)	(8.81)	(0.44)	
M.Bl.	4.92	63.1	0.5	6.17	63.8	1.0	1:30 P.M.
	(1.11)	(10.3)	(0.6)	(1.19)	(11.9)	(0.8)	

In all cases in the table above we find that R for the rest condition is greater than R for the work condition. The rough time measurements signify nothing. Likewise a study of the errors made shows nothing definite.

The experiments were also made upon five untrained subjects, students just finishing their first semester in the elementary laboratory course. They were given twelve experiments, six for each condition. Their averages are given in the following table. No mean variations are given.

TABLE XXV

Subject	Work R	Work Time	Work Er.	Rest R	Rest Time	Rest Er.	Hour of Experiment
R.M.	3.67	78.2	0.67	3.33	86.7	0.50	9 A.M.
H.G.	5.33	84.7	0.17	7.00	67.0	0.30	4 P.M.
L.B.	5.58	92.8	0.25	5.58	80.2	0.40	11 A.M.
G.J.	5.00	69.9	0.67	7.00	69.0	0.67	1:30 P.M.
E.D.	3.20	43.4	0.00	2.80	49.0	0.20	4 P.M.
Total	22.78	369.0	1.76	25.71	351.9	2.07	
Mean	4.56	73.8	0.35	5.14	70.4	0.42	

Two subjects do better after the work, two better after the rest, while one does the same in each, as regards R. The averages for the group indicate a retroactive inhibition. While these results are not convincing, they indicate, if we take the group average, some detrimental influence.

Experiment Series B. Effect of Practice

In the table below we have summarized the averages for the first and last halves of three subjects' completed records. The results are taken from a study of the individual records whose means are given in Table XXIV, preceding.

TABLE XXVI

Subject	Position in Series	Work R	Rest R	Retroaction (Rest–Work)
M.Blf.	First Half	4.83	5.2	0.37
	Last Half	5.00	7.2	2.20
F.C.D.	First Half	4.86	5.6	0.74
	Last Half	5.60	6.70	1.10
R.S.	First Half	5.50	4.83	–00.67
	Last Half	3.83	5.50	1.67

If we measure the amount of retroaction by the formula, R rest minus R work gives the amount of retroaction (where R stands for the amount recalled), then we find, in the case of the above named subjects, that as they become more practiced in the tests retroaction increases. This is true in every case. As our practice period is at most rather short, we can only say that within the limits of practice involved in our present experiments the retroaction became more marked as the practice increased. This is possibly due to the fact that our subjects constantly improved in ability to take an indifferent and passive attitude in the rest period.

Experiment Series C. Position of Experiment in a Day's Experiment Series

If we take the rest and work intervals which occur in the first part of the day's experimental series and compare the retroaction thus found with the retroaction found between work and rest intervals occurring in the last part of the day's series, what

do we find? It will be remembered that a day's experiment series consisted of six individual experiments. We have gone through the results for three subjects, whose means are given in Table XXVII, thus making the comparisons above stated. The following table gives the results:

TABLE XXVII

Subject	Position in Series	R Work	R Rest	Retroaction (R rest–R work)
F.C.D.	First Half	5.78	6.17	0.49
	Last Half	4.67	5.94	1.27
R.S.	First Half	5.00	5.60	0.60
	Last Half	4.20	4.86	0.66
M.Blf.	First Half	4.70	7.00	2.30
	Last Half	5.17	5.33	0.15

The data are not uniform in indication. In the case of F.C.D. there is more retroaction for those experiments occurring near the end of the day's series. The difference is marked and corresponds to his introspections where he believes that he gets worse as the experiments progress in a given sitting. The record for R.S. shows nothing. On the other hand, M.Blf.'s record shows that there is more retroaction for those experiments occurring at the beginning of the day's series. About all we can say is that we have found individual variation in this regard.

Experiment Series D. Effect of Temporal Interpolation

The method of presentation and material were as stated in Experiment Series A, Group (1), with certain changes. A short exposure or learning was again used, the series of words being presented two times. The work consisted in solving simple equation algebra problems. The total length of time between learning and the attempted recall was kept constant in all cases, namely, five minutes. The variable condition is the temporal position of the work. Four different conditions were used, as follows:

(1) L–R3–W2 ..... Recall
(2) L–R2–W2–R1 ..... Recall
(3) L–R1–W2–R2 ..... Recall
(4) L–W2–R3 ..... Recall

All four experiments were done at one sitting, four minutes elapsing between the end of one experiment and the beginning

of the next. The experiments were rotated from day to day. Excepting in the case of the last experiment of the day, the subject did not know, or very seldom, what kind of experiment was next. Unfortunately, only two subjects did this work, namely, I.D.S. and E.B.S., but for these two subjects the experiments were continued until their significance was clear.

If the perseveration view is correct, and our work really involves a good type of concentrated activity, then we should theoretically expect to find least recall when the work followed immediately after the learning; then more recall for Method (3), more yet for Method (2), and most words recalled for Method (1), where we rest for three minutes after learning.

The following table gives the results. The averages are based upon twelve experiments for each of the four different conditions. Experiments were done at 9 A.M. The figures in parentheses give the mean variations.

TABLE XXVIII

	R3 W2			R2 W2 R1			R1 W2 R2			W2 R3		
	R	Er.	T	R	Er.	T	R	Er.	T	R	Er.	T
E.B.S.	3.92	0.5	90.0	3.33	0.25	89.5	3.33	0.08	72.6	1.5	0.17	83.2
	(0.65)		(20.0)	(1.38)		(13.0)	(1.67)		(13.6)	(1.0)		(14.8)
I.D.S.	3.66	1.8	90.3	4.08	1.00	86.1	4.08	1.30	88.3	4.8	0.83	74.7
	(1.47)		(21.8)	(1.10)		(17.4)	(1.75)		(28.3)	(1.8)		(18.7)

Examination of these results shows diametrically opposed results. The record of E.B.S. is in accord with what we might theoretically expect from the standpoint of a perseveration view. The results of I.D.S. would indicate that she does best when the work is introduced immediately. However, the differences between the various methods are all very small and the safest thing to say is that this subject does not experience any greater retroaction when the work follows immediately.

PART IV. EXPERIMENTAL SECTION

NONSENSE SYLLABLES AS ORIGINAL LEARNING MATERIAL

The following experiments attempt to give some light upon the same problems raised in the preceding experimental sections. However, in this section we have used nonsense syllables for the original learning. Nonsense syllables were used in one or the other of two forms, either as series of seven single syllables or as a series of seven paired syllables. Syllables having obvious meanings were thrown out. In any series we attempted to secure a balanced series of syllables with regard to difficulty of pronunciation. No two syllables in a given series began or ended with the same letter and no two syllables had two similar letters in order, as JEC, LEC.

Experiment Series A. Using Single Syllable Series. Comparison of Rest versus Work Intervals

The Shepard exposure apparatus, previously mentioned, was used. Seven nonsense syllables were typewritten in black large sized type upon a strip of white paper which was placed upon the drum of the exposure machine. As there were fourteen stops in a complete drum rotation, and inasmuch as we used only seven syllables, they were so arranged that every other stop of the drum gave a blank exposure. Each syllable was thus exposed for one second, then followed by a blank exposure; then the next syllable was exposed for one second, and so on. The tempo of the presentation was controlled by a silent swinging pendulum. The subject pronounced each syllable aloud once as it was presented. The syllables were exposed three times.

After the exposure the experiment might take either of two forms, as follows: (1) a rest series of three minutes' duration or (2) a work series, consisting of two minutes of concentrated work on mathematical or reasoning problems, such as the Thurs-

tone series A and B; then subject rested one minute. The minute of rest, following the work, was used to give the subject a chance to rest and also to get away from the "work attitude." The subject then tried to recall all syllables possible.

At one sitting six experiments were performed, three involving work and three involving rest intervals. Between two and three minutes elapsed between each experiment. Subjects I.D.S. and E.B.S. alternated every other night as subjects in these experiments. The other subjects performed twice a week.

The following tables give the averages for five trained subjects and fourteen untrained subjects. R stands for the number of correct reproductions; Er. for the errors; and T for the time of reproduction (taken with a stop watch). Half credit was given if two letters, in their proper sequence, were reproduced, as HIG for LIG. The time represents the interval between the signal for recall and the final statement of the subject that no more syllables would come (S. was asked not to "rack his brain" for the syllables). Again introspections have been carefully taken.

TABLE XXIX

SHOWING AVERAGES AND MEAN VARIATIONS FOR FIVE TRAINED SUBJECTS. SERIES A, SINGLE SERIES NON-SENSE SELLABLES. REST VS. WORK INTERVALS

	Work Interval			Rest Interval		
Subject	R	T	Er.	R	T	Er.
I.D.S.	3.31	72.4	0.54	4.23	82.2	0.54
	(1.15)	(16.1)	(0.48)	(0.66)	(18.7)	(0.58)
E.B.S.	2.13	64.1	0.27	2.37	90.9	0.43
	(0.88)	(16.2)	(0.39)	(0.96)	(22.8)	(0.52)
F.C.D.	3.67	63.1	0.60	4.70	76.8	0.43
	(0.73)	(15.9)	(0.52)	(1.26)	(22.4)	(0.23)
M.Blf.	2.92	45.8	0.83	3.88	51.7	0.41
	(1.17)	(9.5)	(0.72)	(0.75)	(17.8)	(0.49)
Sw.	3.75	61.0	0.67	4.30	68.0	0.42
	(0.79)	(13.3)	(0.61)	(1.00)	(13.0)	(0.35)

NOTE.—R stands for number of syllables recalled; T, for time in seconds; Er., for errors. Figures in parentheses stand for mean variation. The times of day when each subject did the experiments and the number of records upon which the average is based are as follows: I.D.S., 7 P.M., 14 records; E.B.S., 7 P.M., 15 records; F.C.D., 8 A.M., 15 records; M.Blf., 1:30 P.M., 12 records; and Sw., 2:30 P.M., 12 records.

TABLE XXX

Sex	Work R.	Work Er.	Work T.	Rest R.	Rest Er.	Rest T.
Female	4.08	0.08	66.7	4.60	0.42	55.7
Female	2.92	1.08	122.0	3.17	1.83	130.4
Female	3.67	1.00	113.6	3.75	0.33	91.8
Female	3.42	0.25	68.7	3.92	0.42	80.2
Female	3.42	0.25	56.3	3.43	1.25	51.8
Female	1.75	2.92	106.2	3.92	1.92	98.0
Male	2.75	0.25	59.0	2.17	0.50	69.8
Male	5.33	0.00	54.2	5.33	0.30	86.0
Male	2.67	0.00	46.0	4.67	0.17	41.2
Male	4.82	0.70	67.0	5.50	0.30	69.0
Male	2.10	0.75	71.2	3.67	0.60	79.8
Male	2.83	0.33	57.2	3.25	0.25	52.3
Male	3.75	1.10	97.7	4.50	0.50	107.3
Male	4.00	0.50	72.0	5.60	0.10	62.3
Total	47.51	7.21	1048.8	57.48	8.89	1083.6
M.	3.39	0.52	74.9	4.10	0.64	77.4
M.V.	0.71			0.79		

Table gives averages for 14 untrained subjects (elementary psychology students). Non-sense syllables, Series A. Experiments done at various times of day from 10 A.M. until 5 P.M. Each average based upon six experiments, total experiments being 12.

A study of Table XXIX (trained subjects) shows in every case that more syllables are recalled after the REST interval. While the difference between the two methods is indeed slight, yet it is consistent and argues for retroaction. The error columns show nothing significant. As regards time of recall, every subject takes longer after the rest interval. The only plausible explanation we can offer for this is that after the work the syllables are gone so completely that, having reproduced a given number, the subject realizes the hopelessness of further attempt. Again, differences in attitude on the part of the subjects may possibly explain the situation.

Table XXX gives the averages for fourteen untrained subjects, based upon six experiments for each of the two kinds of intervals. The students were in the writer's elementary laboratory section, just beginning their laboratory work in psychology, and wholly ignorant of the purpose of the experiment.

The averages for these untrained subjects indicate quite clearly retroactive inhibition. Taking the individual cases, we find that twelve out of fourteen show such retroaction. In one case the method used does not seem to matter, while in one other case the subject does better after the work interval.

On the whole, the above experiments indicate clearly, we believe, a retroactive inhibition, a detrimental influence exerted by vigorous attentive work upon the original learning.

Experiment Series B. Using Method of Paired Associates Testing (1) *Rest versus Work Intervals.* (2) *Similarity of Work and Learning.*

In the following reported experimental section we have tried to get further data on (1) the comparison of rest and work intervals, and (2) by using relatively similar and dissimilar material in the work we have tried to find which type of work brings about the greater inhibition. In these experiments we have used two criteria for inhibition, namely, reaction times and the amount reproduced.

Apparatus and procedure: The exposure apparatus previously mentioned was used, with a reaction time addition. An Hipp, spring driven, chronoscope was used for measuring the reaction times. It was used on a simple make-break circuit, the "make" occurring as the test syllable was shown in the exposure window and the "break" occurring as the subject released the teeth key. The chronoscope was kept tested by means of a gravity chronoscope in which a steel ball, falling through one meter distance, operated the Hipp on a make-break arrangement. Our chronoscope has been fairly constant for our purposes, having a constant error of 28.3 sigma, ± 4.6 sigma.

Seven pairs of syllables were exposed to the subject fifteen times by means of the rotating drum and control lever. A pause of two seconds occurred after the eighth exposure. Each pair of syllables was exposed for one and a half seconds. A blank space was shown at the window between each syllable exposure. The subject pronounced with equal emphasis each pair of syllables as it appeared. Having given the fifteen exposures, any one of the following three procedures might be followed:

I. A rest period of five minutes. Test.

II. A work interval using relatively dissimilar learning material. Here the work consisted either in working simple

arithmetic or algebra problems or else in reasoning out the Thurstone reasoning problems. The work lasted for three minutes, then a rest of two minutes ensued. Test.

III. A work interval using relatively similar material. S. studied another set of seven syllables for one minute; worked for one and one-half minutes on the same material as given in II above; recalled syllables from the work series for one-half minute; rested two minutes. Test.

As will be seen, the total time between learning and testing is in all cases five minutes. In the test for recall the syllables constituting the left side of the pair (from the subject's side) were presented and in the following sequence: 5, 7, 1, 3, 6, 2, 4. (These numbers refer to the position of the syllables in the original learning.) The subject reacted by speaking aloud the associate syllable as soon as the syllable came to mind, or in case nothing came, the subject signified by saying "nothing." In either case the speaking broke the electrical contact and stopped the chronoscope.

The following tables give the results in terms of reaction times and number of associates reproduced, along with errors. We have treated the reaction times in three ways: (1) We have picked out from our records the wholly correct associates and thus compared the three methods; (2) we have combined the wholly right and half right associates; (3) all association times have been lumped together for each method used and thus compared. These thus include right, half right, errors, and reaction times giving "nothing."

If there is a positive retroaction it ought to be manifest in a comparison of Method I with either of the other two methods, II and III. We should expect the shortest reaction times for Method I, involving the rest interval. These results are found for only two subjects, F.C.D. and I.D.S., in the case of the right associates. For the other three subjects the data are conflicting—at least not clear. If we consider the times for correct and half correct associates, we find no evidence for retroaction in the case of any subject. Taking the association times for all reactions

TABLE XXXI

REACTION TIMES, FIVE TRAINED SUBJECTS

Subject	Times for Correct Associates			Times for Correct and Half Correct			Times for All Reactions		
	I	II	III	I	II	III	I	II	III
F.C.D.	3594	4664	4300	4782	4935	4320	6931	7398	5949
	(3126)	(3445)	(2839)	(4104)	(3423)	(2736)	(5929)	(5550)	(3919)
	N,31	N,35	N,31	N,37	N,39	N,34	N,56	N,62	N,54
I.D.S.	2443	2358	3540	2619	2419	3283	3686	3829	4605
	(1362)	(1244)	(1757)	(1555)	(1265)	(1766)	(2312)	(2155)	(2078)
	N,43	N,41	N,39	N,48	N,43	N,42	N,79	N,82	N,82
E.B.S.	3333	2790	2734	3688	2799	2997	4891	4696	4489
	(1856)	(1272)	(1271)	(1962)	(1195)	(....)	(2280)	(1918)	(1945)
	N,29	N,25	N,32	N,33	N,26	N,38	N,83	N,80	N,79
M.Blf.	3074	2866	3490	3314	2785	3460	4378	4062	5029
	(1225)	(1220)	(2100)	(1474)	(1163)	(1970)	(2342)	(2615)	(2510)
	N,23	N,28	N,19	N,31	N,30	N,25	N,56	N,54	N,55
Swk.	3888	4689	3669	3972	4526	3800	6530	7756	7188
	(2817)	(3117)	(1791)	(2697)	(2993)	(2283)	(4778)	(5686)	(4847)
	N,25	N,30	N,24	N,30	N,33	N,26	N,63	N,55	N,52
Group Mean	3266	3474	3547	3675	3493	3572	5283	5548	5452

In the table above the four place figures give the reaction times in sigma and are averages. The figures in parentheses are mean variations. N stands for the number of cases. Column headed I refers to Rest Interval; II, the Work Interval using Dissimilar work material; III, the Work Interval involving Similar work material.

TABLE XXXII

AMOUNT RECALLED AND ERRORS, FIVE TRAINED SUBJECTS

Subject	I. Rest		II. Work, Dissimilar		III. Work, Similar	
	R	Er.	R	Er.	R	Er.
E.B.S.	2.83	0.70	3.08	0.46	2.25	0.67
	(1.08)	(0.74)	(1.24)	(0.38)	(0.75)	(0.38)
I.D.S.	4.20	1.30	3.71	0.79	3.75	1.17
	(0.99)	(0.73)	(1.47)	(0.45)	(1.00)	(0.64)
Swk.	3.15	1.65	4.55	1.39	3.83	1.00
	(0.80)	(0.85)	(1.01)	(0.77)	(1.41)	(1.00)
M.Blf.	3.50	1.89	3.88	1.25	2.88	2.75
	(0.63)	(0.57)	(0.78)	(0.94)	(0.47)	(0.75)
F.C.D.	4.00	1.60	4.22	1.00	4.25	1.62
	(1.00)	(0.75)	(0.96)	(0.66)	(0.94)	(1.03)
Group Mean	3.54	1.43	3.89	0.98	3.39	1.44

Figures given in table are averages. Figures in parentheses give the mean variations.

under each method, we again find our results conflicting. Subjects Swk. and I.D.S. alone give data suggesting retroaction.

Table XXXII gives the amount of recall and errors under the headings R and Er., respectively. Comparing the results again as regards the rest as over against the two work intervals, we find that only one subject, I.D.S., indicates retroaction. Likewise the

group average signifies nothing. A study of the errors made also seems fruitless.

Our work (repeating in many ways the work of DeCamp) with the paired associates method has been largely barren of results. Strangely enough, we secure evidence of retroaction for single series of syllables, but our results are conflicting and often the very reverse of expectation when we used the paired associates material. Our only explanation is that fifteen exposures in this case fixes the associations too securely to permit retroaction. However, this hypothesis hardly seems justifiable as we review the struggles of the subject to recall the associate. A series of experiments must be carried on in which the number of exposures is greatly reduced in order to test this point.

The second problem investigated in this section has to do with the question of the degree of similarity of the work and learning material. A review of the two preceding tables gives the results for five trained subjects. The reaction times for Methods I and II (Table XXXI) show only two cases, when right associates are taken, where the similar work material exerts a greater retroaction than the dissimilar. For the other four subjects the reverse is true. The other studies of the times in the table are likewise conflicting. If the more similar work material exerts greater retroaction than the dissimilar, then we might expect a longer reaction time in the former case. Our results do not indicate that such is the case under the conditions of our experiment. If we turn to the errors and amount recalled (Table XXXII) we find some evidence that the more similar work exerts greater retroaction than the less similar. In three cases R is less for the similar work than for the dissimilar, and in the two cases where the reverse is found the difference is very small. Taking the group averages, there is a slight advantage in the case of the dissimilar work. If we overlook the fact that our reaction times failed to reveal anything, our evidence indicates that the more similar the work and learning, the greater is the retroactive effect.

Experiment Series C. Single Syllables
Similar versus Dissimilar Work

In the following section we have used eight untrained subjects and single series of nonsense syllables. The series of seven syllables was exposed on the rotating drum at the rate of one per 1.2 seconds. Three exposures were given, the subject saying aloud each syllable as it came to view. After the exposure S. either worked for three minutes on Thurstone reasoning problems or else worked for two and one-half minutes studying fourteen new syllables, taking the last half minute to recall these syllables. Six experiments were done at one sitting. Each subject did his experiments at the same time of day, although different subjects did their work at different times.

There were four men and four women, all elementary psychology students having had some laboratory work but no previous work with nonsense syllables. They merely knew the general nature of the experiment, namely, that it had to do with inhibition. In the recall the first syllable was always given to the subject. A perfect recall would thus be six syllables. The time taken in recall was measured by a stop watch. The following table, XXXIII, gives the individual and group averages:

TABLE XXXIII

	Similar			Dissimilar		
	R	Er.	T	R	Er.	T
	0.83	1.70	104.8	1.88	1.50	151.0
	1.75	0.25	45.2	2.92	0.25	48.3
	0.90	0.50	88.2	2.60	0.50	116.4
	1.92	0.75	92.5	2.00	0.67	92.3
	1.00	0.83	46.5	1.33	0.33	75.0
	1.67	1.00	13.5	2.25	1.08	116.7
	2.33	0.50	128.7	3.83	0.50	141.3
	2.08	5.83	103.0	2.33	1.17	140.7
Total	12.48	11.36	622.4	19.14	6.00	881.7
Mean	1.56	1.42	77.8	2.36	0.75	110.2
M.V.	0.48			0.54		

Without exception, every subject recalled more syllables when the work was dissimilar. Likewise the errors made are greater in the case of the similar work. The similar work apparently involves a greater retroaction.

Experiment Series D. Effect of Varying Temporal Position of Interpolated Work, Single Syllables

In the following report series of seven nonsense syllables were used as the original learning material. The method of exposing and learning was similar to that in Experiment Series C. The interpolated work consisted in working algebra and arithmetic problems, and, as such, was a constant condition. The condition which we have tried to vary is the length of time elapsing between original learning and work interpolation. The total time was the same for each experiment, namely, six minutes. Three variant intervals or combinations were used, as follows (figures indicating minutes):

I. L—W3—R3—Test.
II. L—R1—W3—R2—Test.
III. L—R3—W3—Test.

On any experiment day six experiments were done; that is, each of the above three was done twice. An interval of from two to three minutes intervened between each experiment. In the test E. gave S. in every case the first syllable. Thus there remained six syllables to be reproduced. Half credit was given for those syllables in which two consecutive letters were correct.

In the following table, XXXIV, are given the results from five trained subjects. The column headed R gives the average amount reproduced (six being a perfect score); Er. stands for the average error; and T signifies the time taken in recall. Unfortunately, the experiments had to be done at different times of day. E.B.S. and I.D.S. did their experiments at 7 P.M.; F.C.D., at 8 A.M.; Swk., at 2:30 P.M.; and Blf., at 10 A.M.

Taking first the group average, it will be noted that, while the difference is not great, there is a better recall when a rest interval of three minutes intervenes than when the work is introduced immediately. The intermediate combination II, however, gives the best results. The averages for this intermediate method are based upon relatively few records (unfortunately) in the case of three subjects.

Studying the data by subjects, we note that I.D.S. and E.B.S.

give rather clear results, a decreasing value of R as we read across the table from left to right. F.C.D. and Swk., while doing better (apparently) by the Method II, yet indicate in their averages that there is more retroaction when the work is introduced immediately than when a rest of three minutes intervenes. Blf. alone fails to indicate a greater retroaction when the work is introduced immediately. On the whole the data of Table XXXIV indicate that work introduced immediately after learning gives the greatest retroaction.

As a check series some further experiments were done with thirteen untrained subjects. These experiments were similar to the above excepting that the total time was seven minutes rather

TABLE XXXIV

	L–R3–W3			L–R1–W3–R2			L–W3–R3		
Subject	R	Er.	T	R	Er.	T	R	Er.	T
E.B.S.	2.04	0.80	97.3	1.45	0.45	82.5	1.30	0.62	70.4
	(0.97)	(0.63)	(16.8)	(1.04)	(0.58)	(20.5)	(0.10)	(0.50)	(25.4)
	N,12	N,12	N,12	N,11	N,11	N,10	N,12	N,12	N,12
I.D.S.	3.75	0.33	68.0	3.10	0.40	65.4	2.63	0.88	64.0
	(1.04)	(0.44)	(20.0)	(1.22)	(0.40)	(17.7)	(1.15)	(0.86)	(20.7)
	N,12	N,12	N,12	N,10	N,10	N,10	N,12	N,12	N,12
F.C.D.	3.30	0.60	72.0	5.20	0.20	59.0	2.95	0.55	71.0
	(1.24)	(0.46)	(25.0)	(0.32)	(0.32)	(22.0)	(1.17)	(0.54)	(19.0)
	N,10	N,10	N,9	N,5	N,5	N,5	N,10	N,10	N,10
Swk.	3.05	0.45	77.1	4.67	0.00	64.5	2.85	1.05	100.3
	(0.67)	(0.36)	(22.9)	(0.89)	(0.00)	(19.5)	(1.05)	(0.47)	(22.9)
	N,10	N,10	N,10	N,6	N,6	N,6	N,10	N,10	N,10
Blf.	3.95	0.70	54.6	4.30	0.86	41.7	4.20	0.40	51.5
	(1.04)	(0.68)	(10.6)	(0.33)	(0.49)	(6.6)	(1.04)	(0.32)	(6.8)
	N,10	N,10	N,10	N,7	N,7	N,7	N,10	N,10	N,10
Group Aver.	3.22	0.58	73.8	3.75	0.38	62.6	2.79	0.70	71.4

Figures in parentheses give M.V. N signifies number of experiments.

than six. In all cases S. spent the last minute just before recall in glancing through a magazine. Only two combinations were used, the I and III above.

Table XXXV gives the results. The averages are based upon only four experiments for each combination. The work consisted, on the first experiment day, in working out Thurstone reasoning problems and, on the second day, doing simple algebra and arithmetic problems.

The above table indicates nothing definite. The group averages indicate a slightly greater recall when a rest period inter-

TABLE XXXV

Sex	R2 W3 M1 R	Er.	T	W3 R2 M1 R	Er.	T
Male	3.5	0.75	91.2	3.3	0.75	58.2
Male	2.8	0.50	70.2	2.5	1.00	68.5
Male	1.6	0.88	75.5	0.8	2.00	81.0
Male	2.5	1.50	78.2	3.5	1.12	108.0
Female	2.9	1.38	98.2	3.6	1.12	75.0
Male	3.3	0.50	40.9	2.5	0.50	40.7
Male	3.2	0.62	41.5	3.4	0.38	38.2
Female	4.1	0.88	104.7	3.0	0.38	97.5
Male	2.6	0.12	51.7	3.3	0.25	33.5
Male	2.3	0.25	48.2	2.5	0.25	49.0
Female	3.1	1.10	74.8	2.0	0.50	101.2
Female	4.2	0.88	45.0	3.7	1.00	56.7
Male	2.3	0.75	47.0	1.3	1.25	51.2
Total	38.4	11.11	875.2	35.4	10.50	858.7
M.	2.95	0.85	67.3	2.72	0.80	57.3
M.V.	0.57	0.31	18.6	0.73	0.41	20.2

venes before the work, as compared to the condition where the work comes immediately. Seven individuals show greater retroaction when the work comes immediately, while six give opposite results.

Basing our statement on the work of the trained subjects, we may say that there is a positive indication that the temporal position of the work is important.

Experiment Series E. Effect of Varying Temporal Position of Work, Paired Associates Method

The problem investigated in this series is the same as that considered in the Series D preceding. However, we have here tried to test the matter of the importance of the temporal position by using the paired-associates method. The arrangement of the pairs, their presentation, and method of testing was the same as mentioned in Series B preceding. Two different methods were used and compared, as follows:

I. L (15 exposures)—W3—R3—Catalogue 1—Test.
II. L' (15 exposures)—R3—W3—Catalogue 1—Test.

In each of the above methods the subject spent the last minute glancing at the pages of an apparatus catalogue. The records of five trained subjects appear in the following tables, XXXVI and

XXXVII. Three experiments were done at each sitting, two of one method and one of the other. On the day following, this was reversed. The subjects did their experiments at the same times as mentioned in Series B. The presentation of the methods was irregular and S. did not know what to expect next. Table XXXVI gives the means, the mean variations (figures in parentheses), and the number of experiments upon which the means are based. These means represent the average number of syllables (associates) reproduced correctly (column headed R), and the errors (column headed Er.). Table XXXVII gives the reaction times in sigma, the mean variations, and the number of cases.

TABLE XXXVI

Subject	R3 W3 C1 R	R3 W3 C1 Er.	W3 R3 C1 R	W3 R3 C1 Er.
Swk.	4.07	1.57	4.36	1.07
	(1.35)	(0.80)	(0.77)	(0.80)
	N,7	N,7	N,7	N,7
M.Blf.	3.61	1.94	2.55	2.67
	(1.37)	(1.16)	(1.42)	(0.99)
	N,9	N,9	N,9	N,9
F.C.D.	5.00	1.00	4.11	1.00
	(1.22)	(0.55)	(1.12)	(0.67)
	N,9	N,9	N,9	N,9
E.B.S.	2.81	0.89	2.51	0.96
	(0.98)	(0.46)	(1.30)	(0.88)
	N,13	N,13	N,13	N,13
I.D.S.	4.40	1.50	4.80	1.00
	(1.30)	(0.83)	(0.73)	(0.33)
	N,11	N,11	N,12	N,12
Group Mean	3.98	1.38	3.67	1.37

Studying Table XXXVI, we note that the group average indicates an advantage with regard to amount reproduced for the method in which a rest interval of three minutes intervenes between the original learning and work. The errors are the same. Three subjects give more associates when the work is delayed, whereas in two cases (I.D.S. and Swk.) there is a slight advantage for the method which involves the immediate introduction of the work.

Turning now to the reaction times (Table XXXVII) and inspecting first the group average, we note, for the correct associates, that the mean reaction time is 125 sigma longer when the

work is introduced immediately. Considering columns three and four in the table, which give the times for both correct and half correct associates reproduced, we find the same thing, excepting that here the difference is greater, namely, 369 sigma. It will be noted that in the case of Swk. we have used a smaller set of means than that listed above his mean variations. We have taken out three very extreme times from his records and this gave us the smaller averages. These extreme records were thrown out as

TABLE XXXVII

Subject	Reaction Times for Wholly Correct Associates		Reaction Times for Correct and Half Correct Associates	
	R3 W3 C1	W3 R3 C1	R3 W3 C1	W3 R3 C1
Swk.	6026	3965	5564	5375
	(4921)	(2557)	(4268)	(3516)
	N,24	N,27	N,30	N,34
	*3967	3472	3702	3418
Blf.	2701	2465	2699	2903
	(1401)	(1248)	(1327)	(1739)
	N,30	N,20	N,33	N,26
F.C.D.	4149	4580	4111	5236
	(2898)	(3081)	(2768)	(3709)
	N,43	N,35	N,45	N,37
E.B.S.	2775	2368	2941	2333
	(1496)	(1408)	(1583)	(1381)
	N,34	N,32	N,37	N,33
I.D.S.	2327	3660	2447	3854
	(1253)	(2334)	(1370)	(2502)
	N,43	N,54	N,48	N,62
Group Mean	3184	3309	3180	3549

* This row of means used in all calculations.

the subject reported that he had the associate but held on to it overtime. Consequently we have used his smaller average, in which these three very extreme reaction times are omitted from consideration.

Subject Swk. gives a reaction time longer for Method II, although this difference stands out greater than the difference between the two methods as regards amount reproduced. About the same can be said for E.B.S., his reaction times being shorter when he works immediately after the learning. F.Blf. gives a shorter reaction time for Method I (immediate work) in case of correct associates. However, when we consider together the correct and half correct associates given the reverse is true. We

are inclined to stress columns III and IV in our table above for it is these half correct associates which represent the hesitations and blockings noted in the subject's reactions. Considered from the standpoint of either correct or correct and half correct associates, the results from F.C.D. show a longer reaction time when the work follows immediately. While, as we saw above, I.D.S. reproduces as many associates for Method I as for Method II, a study of the reaction times gives a clear case for Method II. The reaction times are longer when the work is introduced immediately.

We believe that a careful analysis of the above results justifies us in saying that the temporal position is important—that work introduced immediately causes more retroaction (as judged by a longer reaction time and a smaller number of recalled associates) than the method wherein the work is not introduced until after three minutes. We have some individual (apparent) exceptions. Some other form of work activity, a longer period of work activity, less number of exposures in the original learning—these and other differing conditions might have yielded us, even for these apparent exceptions, results confirmatory of our above generalization. Certainly we must say that there seem to be individual differences indicated as regards susceptibility to retroaction in the above experiments. The work in Series D, using single syllables, likewise lends weight to our generalizations as stated above.

PART V. EXPERIMENTAL SECTION

GENERAL SUMMARY OF THE INVESTIGATION

There remains the task of bringing together the results of the various experimental series.

I. The experiments involving the reconstruction test for original learning indicate very clearly that it is better to rest after the learning than to turn immediately to some other vigorous and taxing work. That is to say, learning after a rest interval can be recalled better than after a work interval.

The same results have been found in the case of series of sense words as original learning. Likewise the use of single series of nonsense syllables showed the same results. However, when we used series of paired associates and tested by the method of right associates and reaction times, our results were conflicting.

II. Our data indicate that the degree of similarity between the original learning and the interpolated work activity is important. Within limits, the more similar the original learning and the interpolated work the more detrimental will be the effect upon the efficiency of recall of the original material. The matter of " within limits " must be stressed here. The data from the reconstruction test is quite definite in justifying the above statements. In the case of single series of nonsense syllables it was also found that the more similar the work and learning material the greater the detrimental influence on recall of the original learning. Again, the reaction times of the paired-associates (nonsense syllables) experiments failed to give clear results, although the amount reproduced indicates a greater retroaction when the work and learning are similar.

Our work substantiates Robinson's results in the matter of the importance of the degree of similarity of work and original learning. We must hasten to add certain limitations and additions to the general statements preceding:

A. When work and original learning are identical in content and method there is only reinforcement or repetition. There is no inhibition.

B. As the material is made (by degrees) more and more dissimilar the reinforcing factors gradually diminish in effectiveness and the interfering factors become more and more pronounced.

C. As the material of learning and work is made more dissimilar a point is reached where there is a maximum of interference or detrimental influence wrought upon the original learning.

D. Beyond this point the curve of interference or detrimental influence goes downward, and then we can say that the more dissimilar the materials the LESS the detrimental influence.

E. However, the curve of detrimental influence never reaches zero because after the work and learning are as different as can possibly be made there is still a damaging influence exerted by the work.

We have found it very difficult to make out a graded series of work activities differing in degree of similarity from the original learning.

III. All the data which we have accumulated indicate that the temporal position of the interpolated work is important. Work introduced immediately following the original learning is more detrimental in its influence on that original learning than work introduced after a rest interval. Reconstruction test data, single series of nonsense syllables, and paired series of nonsense syllables indicate the above conclusion. The little work done with sense words alone is conflicting.

These results confirm the results found by Müller and Pilzecker and are opposed to the findings of Robinson, who rejects the matter of temporal position of the interpolated work as unimportant.

IV. On the basis of the data from the reconstruction experiments there seems evidence that as the subject becomes more and

more fatigued in the course of the day's series the work activity acts relatively more detrimentally upon the original learning.

Tolman found that there is a more detrimental influence of work upon learning in the evening than in the morning. Our investigation of the relative effects of work activity in the morning and evening, however, fail to confirm Tolman's conclusions. When learning was as good in the evening as in the morning there was no evidence that the work interpolated was more detrimental.

V. As regards the effects of practice, our data are not as positive as we would wish. As the subject becomes more and more practiced with the original learning material will there be less and less detrimental influence exerted by the work activity? Robinson has suggested this. In the case of the sense words our results actually indicate that as the subject becomes more practiced there is an increase in the detrimental action of the work material. The results from the reconstruction test are conflicting.

Our data show that as the subjects become more practiced with the original learning material the learning itself is better, the subject learns more easily, and can retain longer. Certain efficient methods of learning become selected by the trial and error process as one becomes practiced with a given learning material.

VI. Certain general statements may be made here concerning the rest and work periods. Two years of working on this investigation have emphasized to us the following points:

A. Trained subjects are a necessity. One cannot know about the nature of the " rest " interval unless the subject gives a detailed and careful report of what went on " within." Only the subject can tell whether the work activity was " difficult or easy," " interesting or boresome," " attentive or inattentive," etc.

B. The number of " rest " intervals which are near ideal from the standpoint of " mental passivity " and absence of all thought of the original learning is relatively few. Most rest intervals are characterized by either some " return " to consciousness of the original learning or else the subject becomes active mentally upon some line of thought.

C. As subjects become practiced they are better able to take an indifferent and passive attitude during the rest interval.

D. In most cases where there was reported some consciousness of the original learning during the rest interval it was very vague and fragmentary, often taking the form of merely desiring to recall it with a feeling that it was near at hand.

E. It is important that work which will combine interest and maximum effort be secured for the work activity. We have found reasoning problems of a logical and mathematical nature the most satisfactory work material.

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College of City of Detroit

PUBLISHED FOR
The American Psychological Association
By THE PSYCHOLOGICAL REVIEW COMPANY
PRINCETON, N. J.
and ALBANY, N. Y.

Agents: G. E. STECHERT & CO., London (2 Star Yard, Carey St., W. C.)
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